THE James Leffel STANDARD REDUCED AND CASCADE WATER WHEELS

BUILT BY

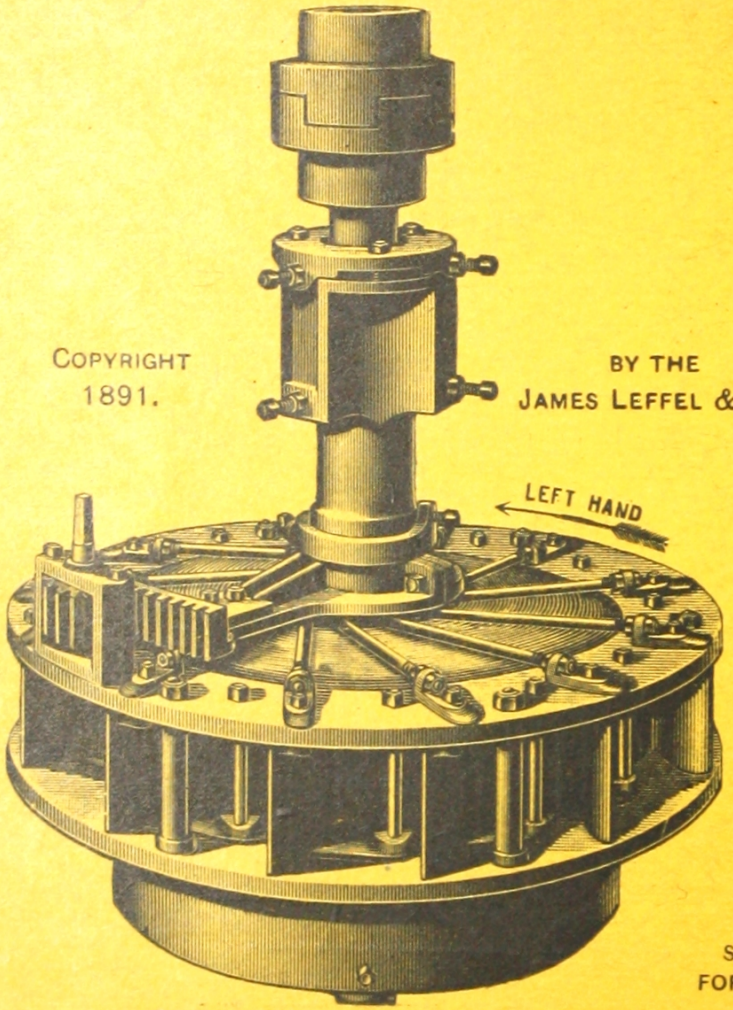
JAMES LEFFEL & Co.

HYDRAULIC AND MECHANICAL ENGINEERS.

SPRINGFIELD, OHIO. U.S.A.

NEW YORK

H. J. A. SMITH—LOUISVILLE.



OLD RELIABLE STANDARD.

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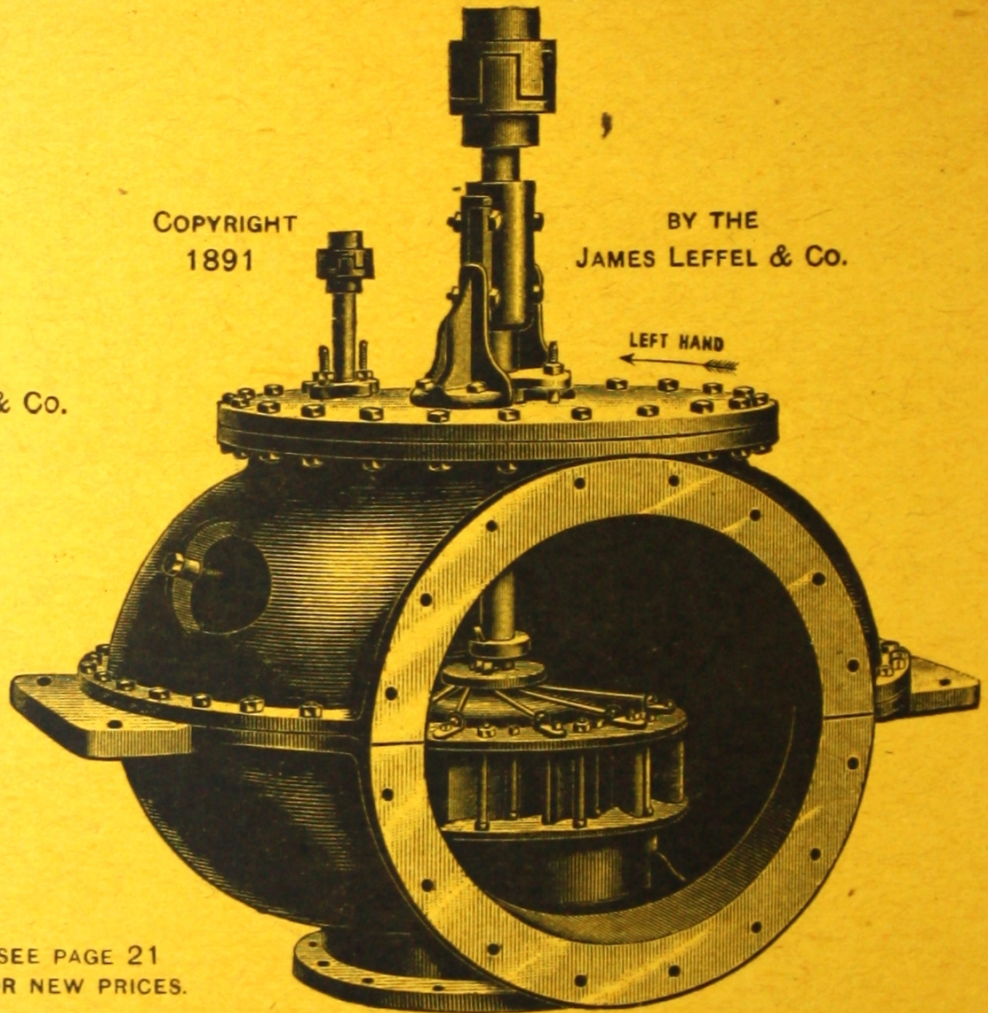


NEW GLOBE CASING.

NEW PAMPHLET

—OF—

The James Leffel Water Wheels

STANDARD CASCADE AND REDUCED.

BUILT BY

THE RELIABLE AND CELEBRATED HOUSE OF

JAMES LEFFEL & CO.

32 YEARS IN BUSINESS.

SPRINGFIELD, OHIO, U.S.A.

AND

NEW YORK CITY.

1894.

110 Liberty St

PREFACE AND INTRODUCTION.

This pamphlet contains some matter, in regard to our James Leffel Wheel, but it is intended especially, for our new Patented Impulse and Reaction or "Hurdy Gurdy" wheel. A description of this wheel will be found in other parts, with preliminary tables of power, quantity of water used, revolutions per minute, miners' inches, etc. These tables are entirely new, and original in several features. The use of fractional parts of horse power, being omitted where practicable; but when retained, the common fraction is substituted for the decimal. Our Company introduced this important change, and improvement in water wheel tables, for which they have the copyright.

Several members of our firm, have had a practical hydraulic experience, extending throughout a period of more than 40 years. They have witnessed the evolution of the Turbine, from the Crude Paddle Wheel, to its present high state of perfection, as exemplified in such wheels as James Leffel & Co. have recently furnished for Niagara Falls. The early, simpler forms of water wheels, were purely of the reaction class, mostly on horizontal shafts, such as the Parker, Rose, and others used in this country. This reaction type of wheels, was succeeded in this country, by the French Fourneyron and Fontaine, as well as other foreign wheels, which added the principle of Pressure to that of Reaction. Improvements were soon afterwards made in this country, by such practical men as James Leffel. Two of the best styles or forms of Pressure and Reaction wheels were combined, obtaining thereby a double wheel; and upon that line, the unexcelled improvements of the James Leffel Turbine were introduced. The Pressure and Reaction wheel, has been very generally applied to moderate heads, throughout this and other countries. It is well adapted to large volumes of water, and head pressure ranging from two to sixty feet, and sometimes even more. The James Leffel Wheel has been used, under head pressure as high as *Three Hundred and Fifty* feet.

A new combination has been invented, in quite recent years, generally known as the "Jet" or "Hurdy Gurdy" wheel. The Impulse and Reaction principles are employed in this water wheel, thus substituting impulse for pressure, but retaining the reaction principle of the turbine. Hereinafter will be shown, by illustrations and descriptions, several forms and styles of a wheel of this character, Patented February, 1891, which we have named our "CASCADE" Wheel; and which we are now prepared to manufacture extensively. It is hoped, therefore, that the following pages devoted especially to this new Patented Impulse and Reaction wheel, will be important to those interested in water power improvements.

JAMES LEFFEL & CO., SPRINGFIELD, OHIO, U. S. A.

Water Power.

The subject of water power, has engaged the attention of mankind from time immemorial. This interest has not been confined to one people, or one community alone; but all nations have utilized its benefits, in some special manner. Perhaps the earliest application and use of this kind of power, was that for irrigation purposes. The simplest method employed, to obtain the power for elevating the water, was a modification of the large or high Undershot or Breast Wheel, carrying a part of the water to the top, which had aided in propelling the wheel at the bottom. The small quantity thus carried, being dropped into a trough near the top, and therein conducted to the tract requiring irrigation. A modern plant, is supplied with a fine system of Turbines, Centrifugal or Reciprocating Pumps, and iron or steel piping, through which the water is forced, in large quantities to any height or distance.

The use of water power has shown rapid advancement, and perfection of application, equally as great in many other directions; and for a multitude of other purposes. The use of the James Leffel Turbine, may be taken as an instance of diversity in the utilization of water power; as this celebrated wheel is driving more than 100 differerent kinds of Mills, Shops, Factories and other power plants. The country's increase in population, its advance in material growth, the extension of its undeveloped territory, and the great inventions rapidly developing, offer new opportunities, for the extension of water power utilization. The wonderful achievements in electrical science, have shown new and unexpected advantages, for streams heretofore considered useless; and the field enlarges, as practical science advances.

The contrast between an ancient irrigation plant, and a modern system, is well illustrated in Street Railway service; where the best Hydraulic Engineering, and the finest Mechanical execution, are supplemented by intelligent electrical advice, in designing and building the successful motive power by water. Such a service is most exacting in its demands, and more difficult to perform, than perhaps any other use made of this kind of power. All streams whether large or small, with heads of great or light pressure, may be utilized by modern Turbines or Hurdy-Gurdy Wheels. It is to the class of high head pressures, and the latter style of wheel, that the following matter is especially devoted.

Measuring Water Power Streams.

The first consideration, in the contemplated development of a water power, is the measurement of the water in the stream; and the height of head or pressure that can be obtained. This Pamphlet will be devoted particularly, to the use of small streams and high heads. It will therefore, be necessary often to ascertain, with a considerable degree of accuracy, the quantity of water afforded; that a wheel may be properly designed or selected, securing thereby the most harmonious arrangement, and the best possible results.

Several methods will be hereinafter illustrated and described; and to make the information quite complete on this subject, large streams are also included. We give our decided preference, however, for small stream measurements, to the weir method commencing on the following page. It is always more easily and cheaply done, and is accurate and reliable, if properly carried out. The method also of Miner's Inches, is described and carefully illustrated, and will be found capable of obtaining results of sufficient accuracy for small streams.

Improving a Water Power. (*Measuring Streams.*)

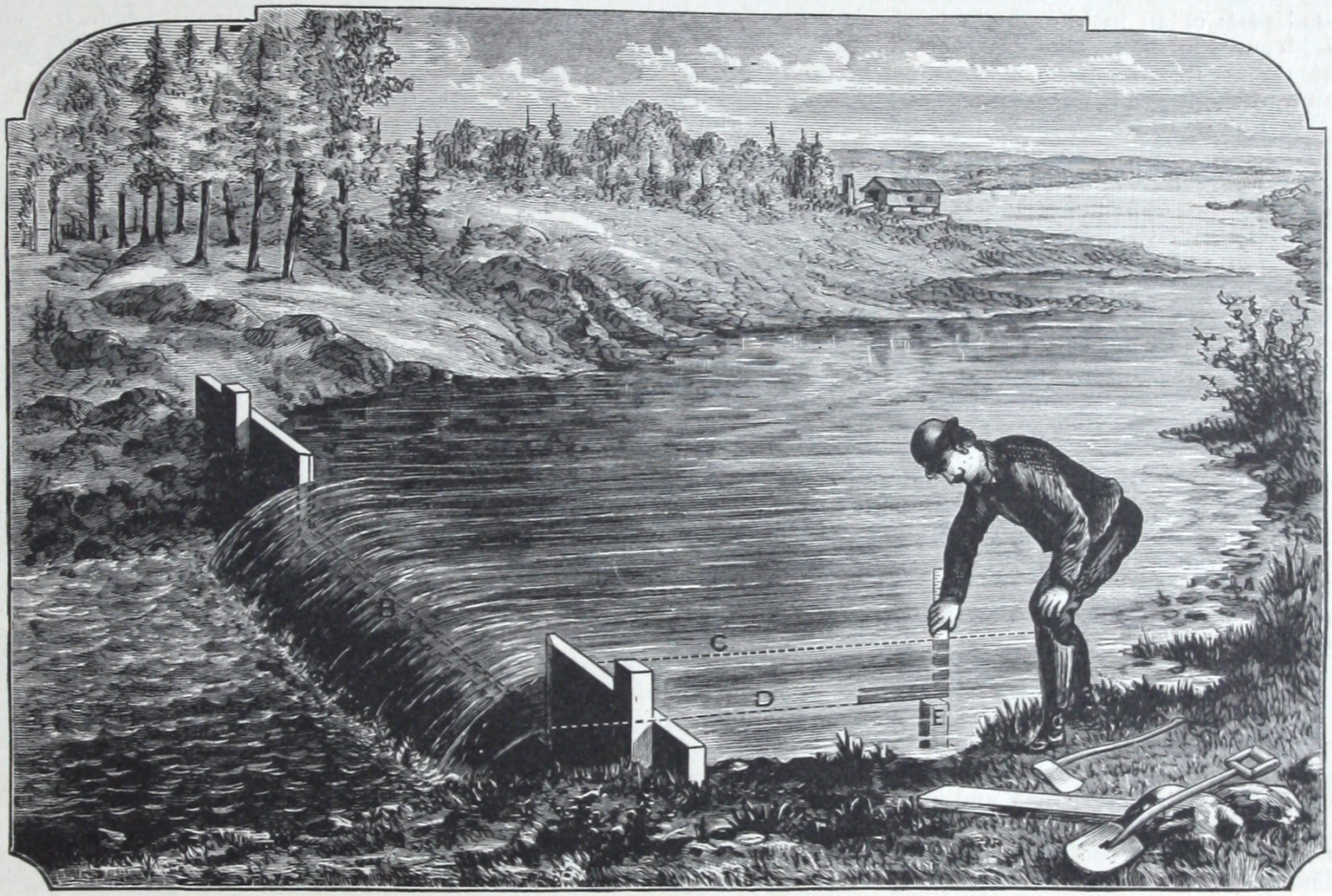
The first thing necessary is to know the amount of head and fall that can be secured. The next step is to ascertain the quantity of water the stream affords. The quantity of water can be closely estimated by the following plain suggestions and the illustration on preceding page. Use a board long enough to reach across the stream, with each end set in the bank. Cut a notch in the board, deep enough to pass all the water, and long enough to reach about two-thirds across the stream. The bottom and ends of the notch B in the board should be beveled on the down stream side, leaving the upper edge al- stream, most sharp. The stake E, should be driven in the bottom of the several feet above the board, on a level with the notch B; this level being easily found, when the water is beginning to spill over the board.

After the water has come to a stand, and reached its greatest depth, a careful measurement can be made of the depth of water over the top of stake E. Such measurement gives the true depth of water passing over the notch, because if measured directly on the notch, the curvature of water would reduce the depth. The line D is a level from the bottom of notch B, to the top of stake E; while the dotted line C represents the top of the water, and the distance between the lines gives the true depth, or spill over the weir board. The line D has the appearance of running over the top of the board; when in fact it passes behind it—the reader is supposed to look through the board and the post. The surface of water after passing below the board, should not be nearer the notch B than ten inches. Neither should the nature of the channel above the board, be such as to force or hurry the water to the board; but should be amply wide and deep, to allow the water to approach the notch quietly. If it passes the channel rapidly, it will be forced over the notch and a larger quantity will pass, than the table indicates.

The weir table herewith gives the number of cubic feet of water passing per minute, over the notch for each inch in breadth. The figures 1, 2, 3, etc., in the first vertical column, are the inches depth of water over the weir; the first or top horizontal line is

Inch.		1/8	1/4	3/8	1/2	5/8	3/4	7/8
1	.40	.47	.55	.65	.74	.83	.93	1.03
2	1.14	1.24	1.36	1.47	1.59	1.71	1.83	1.96
3	2.09	2.23	2.36	2.50	2.63	2.78	2.92	3.07
4	3.22	3.37	3.52	3.68	3.83	3.99	4.16	4.32
5	4.50	4.67	4.84	5.01	5.18	5.36	5.54	5.72
6	5.90	6.09	6.28	6.47	6.65	6.85	7.05	7.25
7	7.44	7.64	7.84	8.05	8.25	8.45	8.66	8.86
8	9.10	9.31	9.52	9.74	9.96	10.18	10.40	10.62
9	10.86	11.08	11.31	11.54	11.77	12.00	12.23	12.47
10	12.71	13.95	13.19	13.43	13.67	13.93	14.16	14.42
11	14.67	14.92	15.18	15.43	15.67	15.96	16.20	16.46
12	16.73	16.99	17.26	17.52	17.78	18.05	18.32	18.58
13	18.87	19.14	19.42	19.69	19.97	20.24	20.52	20.80
14	21.09	21.37	21.65	21.94	22.22	22.51	22.79	23.08
15	23.38	23.67	23.97	24.26	24.56	24.86	25.16	25.46
16	25.76	26.06	26.36	26.66	26.97	27.27	27.58	27.89
17	28.20	28.51	28.82	29.14	29.45	29.76	30.08	30.39
18	30.70	31.02	31.34	31.66	31.98	32.31	32.63	32.96
19	33.29	33.61	33.94	34.27	34.60	34.94	35.27	35.60
20	35.94	36.27	36.60	36.94	37.28	37.62	37.96	38.31
21	38.65	39.00	39.34	39.69	40.04	40.39	40.73	41.09
22	41.43	41.78	42.13	42.49	42.84	43.20	43.56	43.92
23	44.28	44.64	45.00	45.38	45.71	46.08	46.43	46.81
24	47.18	47.55	47.91	48.28	48.65	49.02	49.39	49.76

Weir Table, 1 to 25 Inches.



WEIR DAM MEASUREMENT.

fractional parts of an inch. The body of the table shows the cubic feet, that will pass each minute, for each inch depth of weir, from 1 to 25 inches. Each of these results is for one inch in width; for any particular number of inches width of weir, the result obtained in table, must be multiplied by the number of inches of breadth the weir may be. Suppose the notch in the board is twenty inches wide; and the water at the stake E, 5½ inches deep; in the first column find the figure 5. Follow the horizontal line of figures until a vertical column is reached containing ½ fraction at the top. The square where these two columns meet will contain 5.18 (five and eighteen-hundredths) cubic feet. This is the quantity of water passing for each inch in width; since the supposed weir is twenty inches, this result must be multiplied by 20, which gives 103.6 (one hundred and three and six-tenths) cubic feet per minute. In this manner the water passing any width of weir, of any depth from 1 to 25 inches, can be easily calculated.

An important matter in measuring small streams, is the possibility of damming or holding the water, and using it a part of the time instead of constantly. If the water is held for twelve hours, and the whole quantity used in the next twelve hours, with the supply that the stream affords in the same time, the power of the stream would be doubled, for the twelve hours, and give a better effect than if used constantly. This method may appear simple, but we request that parties give us the depth, and width of the water over the weir, so we can make the calculations ourselves. Always state whether storage room can be had to hold the water part of the time, especially if the stream is a small one.

Measurement of Water by Miners' Inches.

Miners' inch measurement is still another method, of ascertaining the quantity of water flowing in small streams. It is common and frequently practised, throughout mountainous or mining sections of this country. It was early adopted in California, as a means of leasing or letting water to mining claims, by Hydraulic Companies, who invested large sums for reservoirs and ditches, to carry the water for mining purposes. The miners' inch in different regions however, does not always mean the same amount of opening; but we have adopted in this pamphlet a standard opening, recognized by a number of large companies, and their engineers, as a reliable one.

The accompanying illustration will show, and the following power tables contain estimates, based upon this standard opening; which will be 50 inches long, and 2 inches wide, in a 2-inch board; said opening being from its center to the surface of the water, 7 inches, or from the top of the opening to the surface, 6 inches. The opening represents 100 miners' inches, which will discharge 157 cubic feet per minute, ascertained upon reliable and practical experiments by competent engineers. When the opening is narrower or wider, the discharge will differ slightly from that stated; being more with larger and longer openings, and less with smaller and shorter ones. Each miners' inch may, however, be taken at an average of 1.57 (one and fifty-seven hundredths) cubic feet discharge per minute. This will be sufficiently close, in estimating for any size of stream adapted to this method. The plan, however, has not the simplicity and accuracy, in the hands of the ordinary or inexperienced man, as the weir method, already illustrated and described.

The illustration herewith shows an aperture 50 inches long, 2 inches wide, through a 2-inch board. The outside lower edge of the board being chamfered an inch. The slot is shown one-half drawn open; but the board or gate which slides

MINER'S INCH MEASUREMENT.

by means of a rabbit or a shoulder upon the top board, carries a piece fastened to its end, which slides back and forth in the slot, making the spill of water more or less in width, to suit the size of stream, or to keep the depth of the water over this notch, exactly six inches from the surface to the upper edge of the notch. A colored line may be painted on the up stream side of the board, giving the exact height above the notch, or the board itself may be so located, that the width of it above the notch is exactly 6 inches. The moment the water begins to spill over the board, the gate can be further drawn and the opening increased, until precisely the quantity issues through the opening, that will hold the water at the top level of the dam or board, or at the line drawn upon it, to represent the distance above the slot or mortise in the board.

When the gate has been sufficiently drawn, or properly adjusted by means of its handle, so that the upper level of the water will stand exactly at the line, the length of the opening through which the water is passing, can be easily measured. This length multiplied by the two inches opening, gives the exact number of miners' inches. As an instance, if the gate is sufficiently drawn to make the opening 30 inches long, through which the water is spilling, there will be 60 miners' inches, as the notch is 2 inches wide, multiplying the 30 inches by 2 obtains the 60 square inches, or 60 miners' inches. Now, assuming that each miners' inch will discharge 1.57 cubic feet, there will pass 60 times that quantity, or nearly *ninety-five and two-tenths* cubic feet per minute. We stated in the foregoing that where the notch is less in width than 50 inches, it discharges a little less than the quantity or co-efficient we have just named. Our tables giving miners' inches opening, are based upon this style, and kind of measurement; and upon the co-efficient of discharge just named, and may therefore be assumed as nearly correct; sufficiently so for all practical purposes.

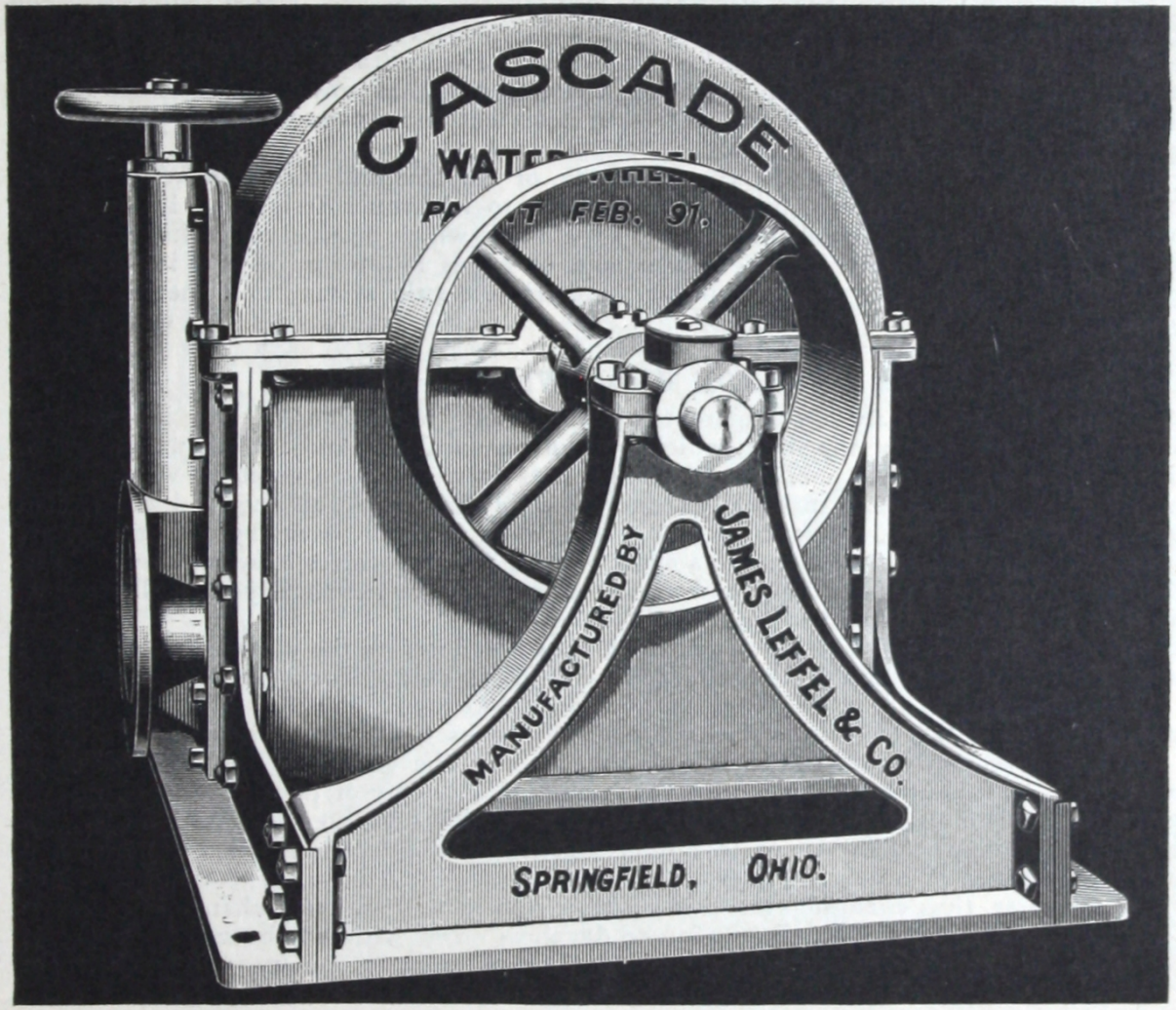
If some other width of notch is taken, or some different depth of water over the notch is used, by parties in their correspondence with us, such measurements should be carefully stated. We would thereby be enabled to estimate the quantity their stream affords, by the particular method then employed. There are different methods used even in the same state, and especially in the different parts of mining and irrigation countries; but the one herein adopted as the standard for the purpose of this book and these tables, seems the most popular and satisfactory.

The New CASCADE Water Wheel.

THE SIMPLEST AND FINEST JET WHEEL NOW BUILT.

Our experience of 32 years building and applying Turbines, has frequently furnished instances, where the Turbine type of Wheel, could not be successfully used. High heads and small quantities of water, require so fine adjustment of various parts of the Turbine, and such close fitting of the movable water joints, that leakage becomes a source of annoyance, and can not be avoided. So many small apertures are also necessary, and therefore so much frictional surface, that the efficiency and percentage utilized, from the quantity of water afforded is seriously affected. The speed of the Turbine is also so great for many uses, that wear becomes rapid and therefore a want of durability.

We have applied the James Leffel Turbine, to heads as high as 350 feet, in capacities ranging from 250 to 1200 Horse Power. The same heads under which these wheels are used, if supplied with very small quantities of water,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CASCADE

could be better utilized by an Impulse and Reaction type of Wheel, such as the Cascade, which will be found hereinafter fully described. Its advantages will be readily seen in the great simplicity of its structure, its slower speed, for many purposes, its small frictional surface, and its almost entire freedom from wear. Besides the foregoing good qualities, this wheel is guaranteed to give a far higher efficiency or percentage of the use of water, than any Turbine under similar conditions. This wheel is also applicable to heads ranging from 40 feet to 2000 feet and upwards; head pressures so high, that they are absolutely impossible of application to Turbines.

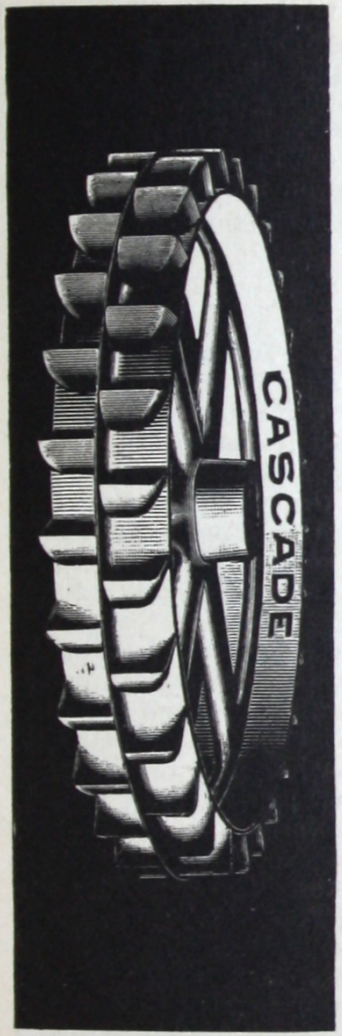
The illustration on foregoing page, shows this new Cascade, Hurdy Gurdy, or Impulse and Reaction Wheel. This Wheel was patented by us February 1891; and by careful thought and attention to its proper design and its strongest, simplest, and best method of construction, it has now reached that state of excellence, which justifies us in its production for the trade. It is shown in this first illustration, in its completed form; and on pages following, parts of its cover are removed, showing the style and character of the runner or wheel proper, the triple nozzle system, and the general internal arrangement in different positions.

Advantages of the CASCADE Water Wheel.

The great simplicity of this Water Wheel is readily apparent upon a mere inspection of the illustrations. There are really no wearing parts except the journals of the shaft, which guarantees durability and a minimum of cost or expense for repair. The application of the water being at one, two, or three points only, its action upon the wheel is very greatly simplified, and the frictional surface of the water materially reduced. The occasional rubbing and consequent wearing of the metal surfaces, causing serious leakage, where close and neat fits are so often necessary in Turbines, are entirely obviated in this wheel. This ease of applying the water to an open bucket, which receives it by impulse and discharges it by re-action, secures the highest possible efficiency in power. Economy in water, especially in small streams, being a matter of great importance, it is successfully secured in this type of our wheel.

Admitting the water to wheel through one, two or more tips or nozzles, does not decrease the useful effect of water; but the percentage remains the same, whether one or more, or a half dozen should be used. Each nozzle increases the power in the direct proportion of the increase of their number, requiring a proportional increase in the quantity of water. This is an advantage of great importance, since there is scarcely any stream that does not vary considerably during a season. Various sizes of nozzles can be conveniently substituted at any time, to suit the changing condition of water supply at all seasons and at all stages; and, as already mentioned, with the same high economy of power.

Another advantage in the use of this wheel is its slower motion than turbines under high heads. With but slight changes or modifications, we can so adapt this wheel in size as to obtain almost any required speed, it being merely a matter of diameter, number of buckets, and size of nozzle. The velocity of the wheel, of course, depending upon the head pressure, and the speed upon the diameter, thus changing the number of revolutions, with every change in diameter of the wheel for the same head. They are easily and frequently applied to dynamos direct without the use of belting or gearing. This is also true as to their application to Centrifugal Pumps, and occasional other machinery. Our experience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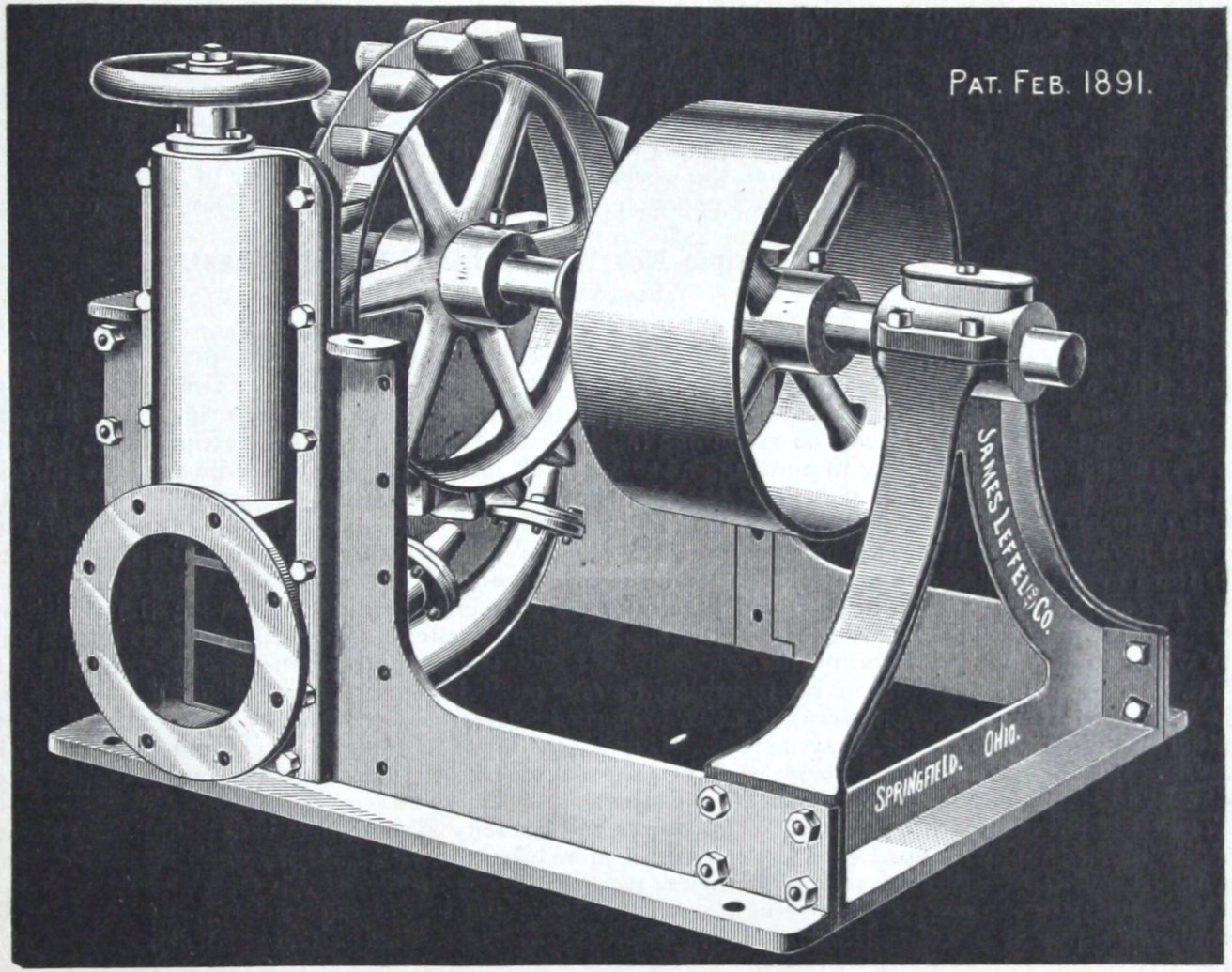
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in the application of water wheels to mining work is extensive; and like the Turbine, this Jet or Impulse wheel can preferably be applied separately to different parts of the same plant. It is often convenient to use a wheel for the Concentrator, another for Electric Lighting Plant, a third for the Batteries, and a fourth for the Stamping and Crushing Department. Each of these different branches of the establishment being run independently of the other, greater regularity is secured in the performance of the entire plant, and either can be stopped and started without interfering with any other department. If one or more departments require an intermittent or irregular power, a governor can be applied to such wheel as may be driving that portion of the works, thus obviating the necessity of using governors on the other wheels. If automatic regulation is necessary, and one water wheel only is used, a large heavy governor must be applied.

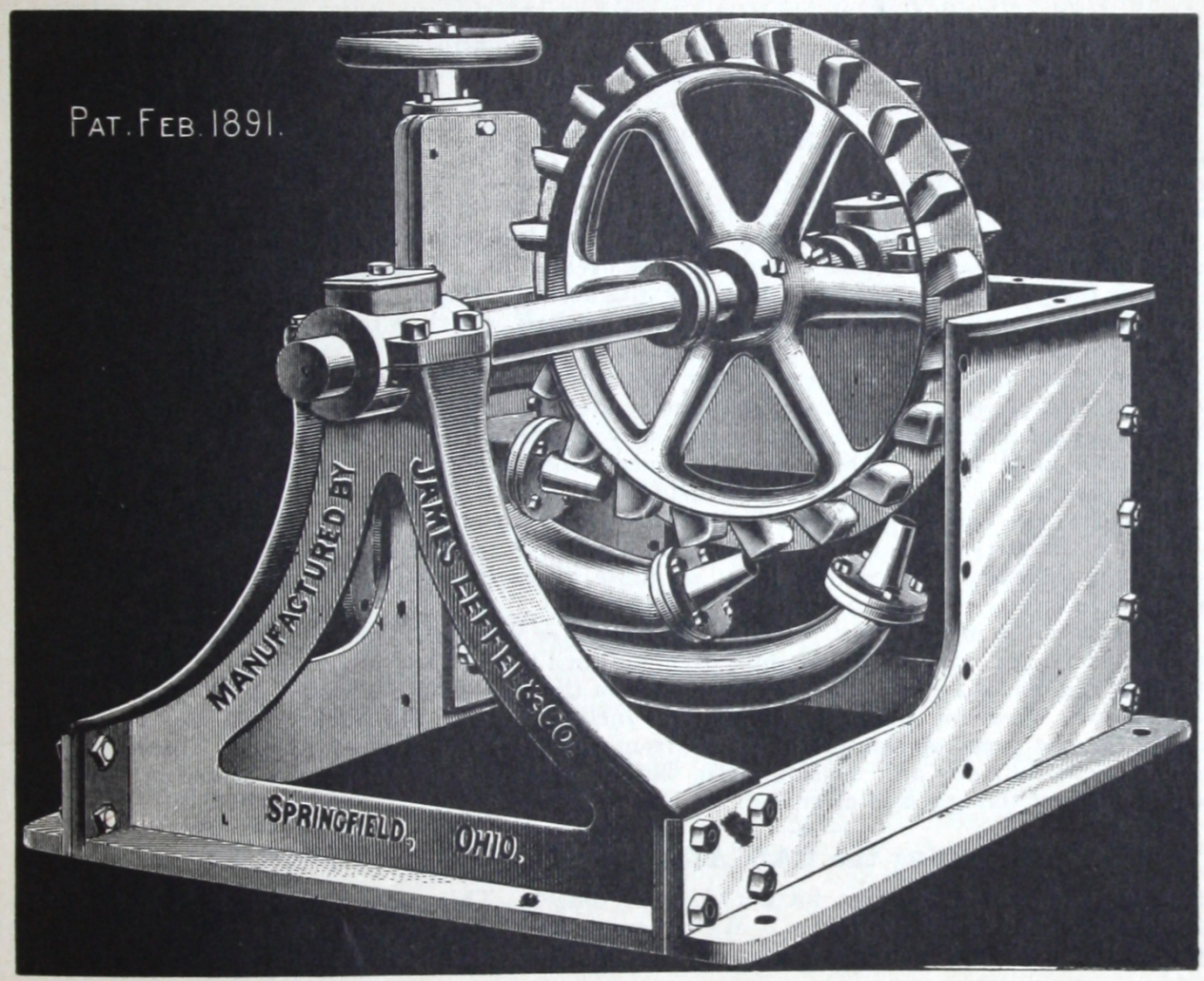
Triple Nozzle CASCADE Water Wheel.

JAMES LEFFEL & CO. SYSTEM.

The following page shows the new Cascade Jet Wheel, already partially described, with its cover and side removed, for the purpose of showing the triple jet system. It will be observed in this plate, as already seen in the preceding plate, that a vertical gate stem and gate are used. This sliding gate covers two partitions between three openings or entrances of the water into the pipes, conducting it to the nozzles or discharge tips. If it is desired to run with but one vent, nozzle or tip, the gate can be raised one third of the distance, or to the first partition, by means of the hand wheel, which turns a screw, operating in a nut upon the gate. If double the amount of power is required, the gate can be raised another third of the distance, embracing two thirds of the entire opening, and stopping upon another partition; thus supplying another tip or nozzle. Should a still further amount of power be desired, or three times the amount of one nozzle, or fifty per cent more than two nozzles, the gate can be run by the hand wheel, to its full height and water admitted to the third nozzle, thus affording a full vent or disharge of the three tips or nozzles.

The same idea is shown in the third illustration, with the side and top removed; the position only of the wheel and frame work being changed. While these nozzles constitute really one piece, the water is admitted separately to each, and the whole branch or system of nozzles, are easily set and fastened within the casing, upon a perfectly tight and planed joint. Our system admits of moving these jets, thereby obtaining the proper inclination or projection upon the buckets of the wheel, without guages, patterns or other means sometimes resorted to, by different makes of wheels of this class. Either of these tips or nozzles, may be removed, and others put in their place, of different size or bore; or either of them may be capped over, and one or more used, or all used together. The system gives a wide range of variability in power, quantity of water used, and fluctuations of the stream.

The two plates show three nozzles. The power and capacity of the wheel is not limited to these three alone; but by a modification of the casing or frame work, three or more others may be added, extending the stream further around the circumference of the wheel or runner. The usual requirements, however, of this class of wheels, will be limited to one, two, or three jets; the number and range of sizes that can be applied, giving variety sufficient to cover a large majority of conditions that may present themselves. We are therefore not limited to this particular style of mounting, or the number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of jets shown in these plates; but we can extend the variety, that we will be able to meet any special or particular case that may arise. Our long experience with water wheels has enabled us to fully master all of the difficulties heretofore presented in the large and varied use and application of the Turbines we have built.

Construction of CASCADE Water Wheel.

It will be seen in the several plates illustrating this wheel, that it has two separate sets of buckets. These buckets are located alternately on each side of a central, sharp, continuous, dividing ridge, projecting a little in front of the entering edge of the buckets. This dividing ridge has a sharp, cutting edge, which edge serves to separate or divide the jet of water before it touches or reaches the buckets, and to keep it continuously divided in two equal portions, so that each portion or each half of this single jet is received separately on each side of the dividing ridge. One half of the jet is therefore received by one series of buckets, separate and independent of the other half, which is received by the other series. Each series of buckets, on each side of this continuous dividing edge, is so arranged that they catch the water alternately, or in such manner that no two come opposite each other, their upper front edges not being on a line.

This alternating arrangement of buckets secures greater steadiness of motion, since it is equivalent to twice the number of buckets, and the shocks or forces are therefore divided more regularly on the wheel, as each bucket passes the point of the nozzle, and catches its half portion of water. These buckets are cast solidly and firmly upon each side of the circular dividing ridge, aud upon the face or rim of the wheel on each side of this central division; this circular ridge being also angular and curved as it approaches the center, giving to the interior of the buckets a very beautiful, symmetrical and effective curve. This arrangement of buckets and form of construction enables us to secure great strength, firmness and stability. They are not subject to the difficulty of becoming loose, as those styles in which bolts, nuts, and other appliances are used to fasten them upon the face or rim of the runner.

Our method of dividing the stream is the most perfect yet applied to Impulse Wheels. The water commences dividing immediately on touching the circular ridge, and continues thus divided until the last portion enters the bucket. The dividing ridge prepares the form of the jet, shaping it to suit the bucket on the side, where it enters or strikes; and thus affords a much better impulsive action; receiving the water against the inclined side of the bucket, which is an essential requisite of the highest efficiency, or the greatest amount of power from the least quantity of water. These points of merit and excellence have had our careful study and consideration, before and since our patent was issued in February, 1891, and will continue to receive our best thought and attention.

Mounting the CASCADE Wheel.

The three plates herewith, illustrate iron mountings for our Cascade Wheel. This style, however, is solid and compact, occupying the least possible space, and is not expensive. We believe it will meet the views and requirements of our customers, more satisfactorily than the method, sometimes employed, of mounting them upon wooden frames. The latter

style may occasionally be somewhat cheaper, but it cannot be by any means as desirable. It is not always convenient to employ a good mechanic for building a wooden mounting, nor can they in any instance be so constructed that they may be as durable, substantial, and as solid as the iron frame work employed by us. This style of mounting is simple, compact, in portable form, and always ready for setting and putting into operation immediately on its arrival, requiring only the necessary attachment to the head pipe.

Our style of mounting admits of easy transportation, in small and comparatively light parts, and great convenience and certainty in setting it up. Each piece can be easily marked and come snugly to its place when assembled or set together. In our construction there is no difficulty in setting and placing the nozzles properly, and thereby greater accuracy of position is attained, and a certainty of higher efficiency or economy in water, because of their certain and proper adjustment. With wooden mountings it is always more or less difficult, to apply the nozzle at its proper angle or inclination, so that the water will strike the buckets at the best position. It is highly necessary that the stream be projected into the buckets just at the right point, to secure the best possible results, with a Hurdy Gurdy or Impulse and Reaction Wheel.

Our Water Wheel Patents.

We have published in several editions of our pamphlet, a decision and decree of the United States Circuit Court, in a suit instituted by the firm of James Leffel & Co., plaintiffs, against Thos. Leffel & Co., the manufacturers of a so-called Leffel Wheel, who were the defendants. This suit was brought to restrain the said Thos. Leffel & Co. from infringing the patents of the James Leffel wheel. The court fully and completely sustained our patents in every particular, absolutely confirming their validity, and a decree was rendered granting an injunction forbidding the manufacture of the said water wheel by the said Thos. Leffel & Co., who soon afterward went out of business.

We beg to remind those who intend buying water wheels, that the wheels made by James Leffel & Co., are not liable to damages, and other annoyances, that often arise in the use of late patented wheels now on the market, which no doubt in many cases, grossly infringe prior patents. We have issued a number of new and important patents, which are the property of our company, and we have never given any rights to their use by lease or otherwise, to any other firm engaged in the water wheel business. These patents are intended for the protection of our own customers, as well as our large and well earned trade.

60, 70 and 80 Inch CASCADE Water Wheels.

The following tables are compiled for three sizes, or three diameters of this new wheel; but we are prepared to furnish smaller wheels and larger ones of the same design. Our works can supply on short notice, 20, 60, 70 or 80 inch wheels, when the necessity of the case requires them. The principal is not limited to any special size, or to those only, mentioned in tables. A want of space prevented a more extended list at this time, but we can give full information, regarding smaller or larger sizes, and of less or even greater capacities, than those to which the tables are adapted.

The facilities of our works, and our long experience in the manufacture and application of water wheels, enables us to furnsh promptly any design, and to advise fully and competently, as to the application of this type of wheel, under any

combination of circumstances, that may arise. It is hoped that those requiring wheels, of this class, or the Turbine type, will not hesitate to write us fully, making any inquiry, that they may desire answered, when it will receive our prompt and special attention.

Tables of the CASCADE Water Wheel.

HEAD, POWER, VELOCITY, MINERS' INCHES AND QUANTITY OF WATER.

The opposite page contains a table of our 26-inch CASCADE Wheel. This table is unique and original in a number of respects. The first vertical column gives head pressures, ranging from 60 to 240 feet; at intervals of every 5 feet, from 60 to 195 feet; and intervals of 10 feet, from 200 to 240 feet. The right hand half page continues these head pressures, from 250 to 740 feet—a portion being at intervals of 10 feet each, and the balance of 20 feet differences. The second vertical column, in both parts of this table, gives the number of revolutions per minute that this 26-inch Cascade Wheel will make, while at labor under each of the heads, opposite to which it is set. Powers, revolutions, and water discharged, for higher heads than those given in the tables, can be estimated in the following simple manner: *Four times* the head, gives *eight times* the power, *two times* the water, and *twice* the revolutions. Example :—Page 18, a 38 inch wheel, 60 ft. head, makes 158 revolutions, gives 3 H. P., and uses 32 cubic feet of water. Multiply the head by 4, the power by 8, the revolutions by 2, and the water by 2; there will be 240 ft. head, 316 rev., 24 H. P., and 64 cu. ft. of water, all of which will be found in the bottom line of the table. The results differ a mere trifle in some instances, but the general rule holds good. For 2000 ft. head, multiply the power under 500 ft. head by 8, the revolutions by 2, the quantity of water by 2, and you have the general result. Estimates for any head, above those in the table, obtained in the same manner.

The vertical columns following, at the head of each of which is found "H. P.," represent the horse-power that will be obtained, with each of the head pressures for this size of wheel. In giving these horse powers we have omitted decimal fractions, and give only the nearest common fraction, as we have done in our tables for the James Leffel Turbine—we being the first parties to originate and adapt this system and plan, which we regard far more simple, and better suited to our general class of correspondents, than where the decimal is retained. The vertical columns with "C. F." at the head of each, show the number of cubic feet of water discharged per minute, for each horse-power just preceding it in the horizontal line, and for each of the vents under each of the head pressures named. We have adopted the same plan in dropping the decimals in giving the cubic feet, as we have done with the horse-power. Each of the columns, at the head of which is found "M. I.," represent the Miners' Inches, already fully explained on page 9, that will give the horse power, and cubic feet of water discharged, just preceding in the horizontal line and under the head pressure, to which each of these are opposite. While the common fraction gives these quantities approximately by eighths, it may not be quite so accurate as the decimals, which gives it by tenths and hundredths; but they are sufficiently close and so nearly correct, as to answer every purpose that the customer may desire. The beauty, simplicity and convenience of this style, recommends itself to every correspondent, and every user of water wheels. The table gives four vents and discharges for this 26-inch wheel, which are seen in a third horizontal line, at the head of the table, reading Vent F, Vent H, etc. The wheel can be built for either one or all of these vents, if the circumstances in the case require it. All that (*See page* 21.)

26 Inch 'CASCADE' Water Wheel.

Head in Feet.	Rev. per Min.	Vent F.			Vent H.			Vent 2 H.			Vent 3 H.		
		H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.
60	237							3 5/8	38 3/4	24 3/4	5 3/8	58 1/4	37
65	247							4	40 1/2	25 3/4	6 1/8	60 1/2	39
70	256							4 1/2	42	26 3/4	6 7/8	62 3/4	40
75	265							5	43 1/2	27 3/4	7 1/2	65	41
80	274				2 3/4	22 1/2	14 1/4	5 1/2	44 3/4	28 1/2	8 3/8	67 1/4	43
85	282				3	23	14 3/4	6	46 1/4	29 1/2	9 1/8	69 1/4	44
90	291				3 1/4	23 3/4	15 1/4	6 1/2	47 1/2	30 1/4	10	71 1/4	45
95	299				3 5/8	24 1/2	15 1/2	7 1/4	48 3/4	31	10 3/4	73 1/4	47
100	306	2 5/8	16 3/4	10 1/2	3 7/8	25	16	7 3/4	50	32	11 5/8	75 1/4	48
105	314	2 3/4	17	11	4 1/8	25 3/4	16 1/4	8 3/8	51 1/4	32 3/4	12 1/2	77	49
110	321	3	17 1/2	11 1/4	4 1/2	26 1/4	16 3/4	9	52 1/2	33 1/2	13 1/2	78 3/4	50
115	329	3 1/8	18	11 1/2	4 3/4	27	17	9 1/2	53 3/4	34 1/4	14 3/8	80 1/2	51
120	336	3 3/8	18 1/4	11 3/4	5 1/8	27 1/2	17 1/2	10 1/4	55	35	15 1/4	82 1/4	52
125	343	3 5/8	18 3/4	12	5 3/8	28	17 3/4	10 7/8	56	35 3/4	16 1/4	84	54
130	349	3 7/8	19	12 1/4	5 3/4	28 1/2	18 1/4	11 1/2	57	36 1/2	17 1/4	85 3/4	55
135	356	4	19 1/2	12 1/2	6	29	18 1/2	12 1/4	58 1/4	37	18 1/4	87 1/4	56
140	362	4 1/4	19 3/4	12 5/8	6 3/8	29 1/2	18 3/4	12 7/8	59 1/4	37 3/4	19 1/4	89	57
145	369	4 1/2	20 1/4	12 3/4	6 3/4	30 1/4	19 1/4	13 1/2	60 1/2	38 1/2	20 3/8	90 1/2	58
150	375	4 3/4	20 1/2	13	7 1/8	30 3/4	19 1/2	14 1/4	61 1/2	39	21 3/8	92	59
155	381	5	20 3/4	13 1/4	7 1/2	31 1/4	20	15	62 1/2	39 3/4	22 1/2	93 1/2	60
160	388	5 1/4	21 1/4	13 1/2	7 7/8	31 3/4	20 1/4	15 3/4	63 1/2	40 1/2	23 1/2	95	61
165	394	5 1/2	21 1/2	13 3/4	8 1/4	32 1/4	20 1/2	16 1/2	64 1/2	41	24 5/8	96 1/2	62
170	399	5 3/4	21 3/4	13 7/8	8 5/8	32 3/4	20 3/4	17 1/4	65 1/2	41 3/4	25 3/4	98	62 1/2
175	405	6	22	14	9	33	21	18	66 1/2	42 1/4	27	99 1/2	63
180	411	6 1/4	22 1/2	14 1/4	9 3/8	33 1/2	21 1/2	18 3/4	67 1/4	42 3/4	28 1/8	101	64
185	417	6 1/2	22 3/4	14 1/2	9 3/4	34	21 3/4	19 1/2	68	43 1/2	29 1/4	102	65
190	422	6 3/4	23	14 5/8	10 1/8	34 1/2	22	20 3/8	69	44	30 1/2	103	66
195	428	7	23 1/4	14 7/8	10 5/8	35	22 1/4	21 1/4	70	44 3/4	31 3/4	105	67
200	433	7 3/8	23 3/4	15	11	35 1/2	22 1/2	22	70 3/4	45 1/4	33	106	68
210	440	7 7/8	24 1/4	15 1/2	11 7/8	36 1/4	23 1/4	23 5/8	72 1/2	46 1/4	35 1/2	109	69
220	454	8 3/8	24 3/4	15 3/4	12 5/8	37	23 1/4	25 3/8	74 1/4	47 1/4	38	112	71
230	465	9	25 1/4	16	13 1/2	38	24 1/4	27	75 3/4	48 1/4	40 5/8	114	72
240	475	9 5/8	26	16 1/2	14 1/2	38 3/4	24 3/4	28 7/8	77 1/2	49 1/2	43 1/4	116	74

26 Inch 'CASCADE' Water Wheel.

Head in Feet.	Rev. per Min.	Vent F.			Vent H.			Vent 2 H.			Vent 3 H.		
		H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.
250	484	10 1/4	26 1/2	16 3/4	15 3/8	39 3/4	25 1/4	30 3/4	79 1/4	50 1/2	46	119	76
260	494	10 7/8	27	17 1/4	16 1/4	40 1/2	25 3/4	32 1/2	80 3/4	51 1/2	48 7/8	121	77
270	503	11 1/2	27 1/2	17 1/2	17 1/4	41 1/4	26 1/4	34 1/2	82 1/2	52 1/2	51 5/8	124	79
280	513	12 1/8	28	17 3/4	18 1/4	42	26 3/4	36 3/8	83 3/4	53 1/2	54 1/2	126	80
290	522	12 3/4	28 1/2	18	19 1/8	42 3/4	27 1/4	38 3/8	85 1/2	54 1/2	57 1/2	128	82
300	531	13 1/2	29	18 1/2	20 1/4	43 1/2	27 3/4	40 3/8	86 3/4	55 1/4	60 1/2	130	83
310	539	14 1/8	29 1/2	18 3/4	21 1/8	44	28	42 3/8	88 1/4	56 1/4	63 1/2	132	84
320	548	14 3/4	30	19	22 1/4	44 3/4	28 1/2	44 1/2	89 3/4	57	66 1/2	134	86
330	557	15 1/2	30 1/4	19 1/4	23 1/4	45 1/2	29	46 1/2	91	58	69 3/4	137	87
340	565	16 1/4	30 3/4	19 3/4	24 3/8	46 1/4	29 1/2	48 5/8	92 1/2	58 3/4	73	139	88
350	573	17	31 1/4	20	25 3/8	46 3/4	30	50 7/8	93 3/4	59 3/4	76 1/4	141	90
360	581	17 5/8	31 3/4	20 1/4	26 1/2	47 1/2	30 1/4	53	95	60 1/2	79 3/4	143	91
370	589	18 3/8	32 1/4	20 1/2	27 5/8	48 1/4	30 3/4	55 1/4	96 1/2	61 1/2	82 3/4	145	92
380	597	19 1/8	32 1/2	30 3/4	28 3/4	48 3/4	31	57 1/2	97 1/2	62	86 1/4	147	93
390	605	20	33	21	30	49 1/2	31 1/2	59 3/4	99	63	89 3/4	149	95
400	613	20 3/4	33 1/2	21 1/4	31	50	32	62 1/8	100	64	93 1/4	150	96
420	628	22 1/4	34 1/4	21 3/4	33 3/8	51 1/4	32 3/4	66 7/8	103	65 1/2	100	154	98
440	643	23 7/8	35	22 1/4	35 7/8	52 1/2	33 1/2	71 5/8	105	67	107	158	100
460	657	25 1/2	35 3/4	22 3/4	38 1/4	53 3/4	34 1/4	76 5/8	107	68 1/2	115	161	103
480	671	27 1/4	36 1/2	23 1/4	40 3/4	55	35	81 5/8	109	70	122	165	105
500	685	29	37 1/4	23 3/4	43 3/8	56	35 3/4	86 3/4	112	71 1/2	130	168	107
520	699	30 5/8	38	24 1/4	46	57	36 1/4	92	114	72 1/2	138	171	109
540	712	32 1/2	38 3/4	24 3/4	48 3/4	58	37	97 1/2	116	74	146	174	111
560	725	34 1/4	39 1/2	25	51 1/2	59	37 1/2	102	118	75 1/4	154	177	113
580	738	36 1/8	40 1/4	25 1/2	54 1/8	60 1/4	38 1/2	108	120	76 3/4	163	181	115
600	750	38	40 3/4	26	57	61 1/4	39	114	122	78	171	184	117
620	763	40	41 1/2	26 1/2	60	62 1/2	39 3/4	120	125	80	179	187	119
640	775	42	42 1/4	27	62 3/4	63 1/2	40 1/4	125	127	81	188	190	121
660	787	43 3/4	43	27 1/2	66	64 1/2	41	131	129	82	197	193	123
680	799	46	43 1/2	27 3/4	68 3/4	65 1/4	41 1/2	137	131	83	206	196	125
700	811	48	44 1/4	28 1/4	72	66 1/4	42 1/4	143	133	84	215	199	127
720	822	50	44 3/4	28 1/2	75	67 1/4	42 3/4	150	135	86	225	202	129
740	833	52	45 1/2	29	78 1/2	68 1/4	43 1/2	156	136	87	234	205	130

REV. PER MIN.=Revolutions per Minute. H. P.=Horse Power. C. F.=Cubic Feet Water per Minute. M. I.=Miner's Inches.

38 Inch "CASCADE" Water Wheel.

Head in Feet.	Rev. per Min.	Vent J.			Vent L.			Vent 2 L.			Vent 3 L.		
		H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.
60	158	3	32	20	4¼	45	29	8⅜	90	58	12⅝	136	87
65	165	3⅜	33½	21	4¾	47	30	9½	94	60	14¼	141	90
70	171	3¾	35	22	5⅜	49	31	10⅝	98	62	16	147	93
75	177	4¼	36	23	5⅞	51	32	11¾	101	65	17⅝	152	97
80	183	4⅝	37	24	6½	52	33	13	105	67	19½	157	100
85	188	5	38½	24½	7⅛	54	34	14¼	108	69	21¼	162	103
90	194	5½	40	25	7¾	55½	35	15½	111	71	23¼	166	106
95	199	6	41	26	8⅜	57	36	16¾	114	73	25⅛	171	109
100	204	6½	42	26½	9	58½	37	18⅛	117	75	27⅛	175	112
105	209	7	43	27	9¾	60	38	19½	120	76	29¼	180	115
110	214	7½	44	28	10½	61	39	21	123	78	31⅜	184	117
115	219	8	45	28½	11⅛	63	40	22⅜	125	80	33½	188	120
120	224	8½	46	29	11⅞	64	41	23¾	128	82	35¾	192	122
125	228	9	47	29½	12⅝	65	42	25⅜	131	83	38	196	125
130	233	9⅝	48	30	13⅜	67	42½	26⅞	133	85	40¼	200	127
135	237	10⅛	48½	31	14¼	68	43	28⅜	136	87	42⅝	204	130
140	242	10¾	49	31½	15	69	44	30	138	88	45	208	132
145	246	11¼	50	32	15¾	70	45	31⅝	141	90	47½	211	135
150	250	11⅞	51	32½	16⅝	72	45½	33¼	143	91	50	215	137
155	254	12½	52	33	17½	73	46	35	146	93	52½	218	139
160	258	13⅛	53	33½	18⅜	74	47	36⅝	148	94	55	222	141
165	262	13¾	53½	34	19¼	75	48	38⅜	150	96	57½	225	144
170	266	14⅜	54	34½	20	76	48½	40⅛	153	97	60¼	229	146
175	270	15	55	35	21	77	49	42	155	99	63	232	148
180	274	15⅝	56	35½	21⅞	78	50	43¾	157	100	65½	235	150
185	278	16¼	57	36	22¾	80	51	45½	159	101	68¼	239	152
190	281	17	57½	36½	23¾	81	51½	47⅜	161	103	71¼	242	154
195	285	17⅝	58	37	24⅝	82	52	49⅜	163	104	74	245	156
200	289	18¼	59	37½	25⅝	83	53	51¼	165	105	77	248	158
210	296	19⅝	60½	38½	27½	85	54	55¼	170	108	82¾	254	162
220	303	21⅛	62	39½	29½	87	55	59	174	111	88½	260	166
230	310	22½	63	40	31⅝	88	56	63¼	177	113	94¾	266	169
240	316	24	65	41	33⅝	90	58	67¼	181	115	101	272	173

38 Inch "CASCADE" Water Wheel.

Head in Feet.	Rev. per Min.	Vent J.			Vent L.			Vent 2 L.			Vent 3 L.		
		H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.
250	323	25½	66	42	35⅞	92	59	71¾	185	118	107	277	177
260	329	27⅛	67	43	38	94	60	76	189	120	114	283	180
270	336	28¾	69	44	40⅛	96	61	80¼	192	122	120	288	184
280	342	30⅜	70	44½	42⅜	98	62	84¾	196	125	127	294	187
290	348	32	71	45	44¾	100	63	89½	199	127	134	299	190
300	354	33⅝	72	46	47	101	64	94¼	203	129	141	304	194
310	360	35⅜	74	47	49⅜	103	65	98¾	206	131	148	309	197
320	365	37	75	47½	51¾	105	66	103	209	133	155	314	200
330	371	38¾	76	48	54¼	106	67	108	212	135	163	319	203
340	377	40½	77	49	56¾	108	68	113	216	137	170	323	206
350	382	42⅜	78	50	59¼	109	69	118	219	139	178	328	209
360	387	44⅛	79	50½	61¾	111	70	123	222	141	185	333	212
370	393	46	80	51	64½	113	71	129	225	143	193	337	215
380	399	48	81	52	67	114	72	134	228	145	201	341	217
390	403	49⅞	82	52½	69¾	116	73	139	231	147	209	346	220
400	408	51¾	84	53	72½	117	74	145	234	149	217	351	224
420	419	55¾	86	54½	78	120	76	156	240	153	233	359	229
440	428	59¾	88	56	83½	123	78	167	245	156	250	368	234
460	438	63⅞	90	57	89¼	125	80	178	251	160	268	376	240
480	447	68	91	58	95¼	128	82	190	256	163	285	384	245
500	457	72¼	93	59	101	131	83	202	262	167	303	392	250
520	466	76¾	95	60	107	133	85	214	266	169	322	398	254
540	475	81¼	97	62	113	136	86	227	271	173	340	407	259
560	483	85¾	98	63	120	138	88	240	276	176	360	413	263
580	492	90¼	100	64	126	141	90	253	281	179	380	422	268
600	500	95	102	65	133	143	91	266	286	182	399	429	273
620	509	100	104	66	139	146	93	279	291	186	419	437	278
640	517	104	106	67	146	148	94	293	296	189	439	444	283
660	525	109	107	68	153	150	96	307	301	191	460	451	287
680	533	114	109	69	160	153	97	321	305	194	481	458	291
700	540	119	111	70	167	155	99	335	309	197	502	464	296
720	548	125	112	71	175	157	100	350	314	200	525	471	300
740	556	130	114	72	182	159	101	364	318	203	546	477	304

REV. PER MIN.=Revolutions per Minute. H. P.=Horse Power. C. F.=Cubic Feet Water per Minute. M. I.=Miner's Inches.

50 Inch ".CASCADE" Water Wheel.

Head in Feet.	Rev. per Min.	Vent N.			Vent P.			Vent 2 P.			Vent 3 P.		
		H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.
60	119	7¼	77¾	49½	12	129	82½	24	259	165	36	388	247
65	123	8⅛	80¾	51½	13½	135	86	27⅛	269	172	40⅝	404	257
70	128	9	83¾	53½	15⅛	140	89	30¼	280	178	45½	419	267
75	133	10	86¾	55¼	16¾	145	92	33⅝	289	184	50½	434	277
80	137	11⅛	89¾	57	18½	149	95	37	299	190	55½	448	286
85	141	12⅛	92½	58¾	20¼	154	98	40½	308	196	60¾	462	294
90	145	13¼	95	60½	22	159	101	44¼	317	202	66¼	476	303
95	149	14⅜	97¾	62¼	24	163	104	47⅞	326	207	71¾	489	311
100	153	15½	100	64	25⅞	167	106	51¾	334	213	77½	501	319
105	157	16¾	103	65½	27⅞	171	109	55¾	342	218	83½	514	327
110	161	18	105	67	29⅞	175	112	59¾	350	223	89½	526	335
115	164	19⅛	108	68	32	179	114	63¾	358	228	95¾	538	342
120	168	20⅜	110	70	34	183	117	68	366	233	102	549	350
125	171	21¾	112	71	36⅛	187	119	73¼	374	238	108	560	357
130	175	23	114	73	38⅜	191	121	76¾	381	243	115	572	364
135	178	24⅜	116	74	40⅝	194	124	81¼	388	247	122	582	371
140	181	25¾	119	76	42⅞	198	126	85¾	395	252	128	593	378
145	184	27⅛	121	77	45⅛	201	128	90¼	402	256	135	604	384
150	188	28½	123	78	47½	205	130	95	409	261	142	614	391
155	191	30	125	79	50	208	133	99¾	416	265	150	624	398
160	194	31⅜	127	81	52½	211	135	104	423	269	157	634	404
165	197	33	129	82	54¾	215	137	110	429	273	165	644	410
170	200	34⅜	131	83	57¼	218	139	115	436	277	172	654	416
175	203	36	133	84	60	221	141	120	442	282	180	663	422
180	206	37½	135	85	62½	224	143	125	448	285	187	672	428
185	208	39⅛	136	87	65	227	145	130	454	289	195	682	434
190	211	40⅝	138	88	67¾	230	147	135	461	293	203	691	440
195	214	42¼	140	89	70½	234	149	141	467	297	211	701	446
200	217	43⅞	142	90	73¼	236	151	146	473	301	220	709	452
210	222	47¼	145	93	78¾	242	154	158	484	308	236	726	463
220	227	50½	149	95	84½	248	158	169	496	316	253	744	473
230	232	54¼	152	97	90¼	253	161	181	506	322	270	759	483
240	237	57¾	155	99	96¼	259	165	192	518	330	289	777	494

50 Inch "CASCADE" Water Wheel.

Head in Feet.	Rev. per Min.	Vent N.			Vent P.			Vent 2 P.			Vent 3 P.		
		H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.
250	242	61¼	159	101	102	264	168	205	528	337	307	793	505
260	247	65¼	162	103	108	269	172	217	539	343	326	808	515
270	251	68¾	165	105	114	275	175	230	549	350	344	824	524
280	256	72¾	168	107	121	280	178	243	559	356	364	839	534
290	261	76¾	171	109	128	285	181	256	569	362	383	854	544
300	265	80¾	174	111	134	289	184	269	579	369	403	868	553
310	270	84¾	177	112	141	294	187	282	588	375	424	883	562
320	274	88¾	179	114	148	299	190	296	598	381	444	897	571
330	278	93	182	116	155	304	193	310	607	387	465	911	580
340	282	97¼	185	118	162	308	196	325	616	392	487	924	589
350	287	101	188	119	169	313	199	339	625	398	508	938	597
360	291	106	190	121	177	317	202	354	634	404	530	951	606
370	295	110	193	123	184	321	205	368	643	409	552	964	614
380	299	115	195	124	192	325	207	383	650	414	575	975	621
390	303	119	198	126	199	330	210	397	660	420	598	990	630
400	306	124	201	128	207	334	213	414	668	426	621	1003	638
420	314	133	205	131	223	342	218	446	685	436	668	1027	654
440	321	143	210	134	239	350	223	478	701	446	717	1052	670
460	329	153	215	137	255	358	228	511	717	456	766	1075	685
480	336	163	220	140	272	366	233	544	732	466	816	1098	699
500	343	173	224	143	289	374	238	579	747	476	868	1121	714
520	349	184	228	145	307	379	242	614	759	483	921	1138	725
540	356	195	232	148	325	388	247	650	775	493	974	1163	740
560	362	205	236	151	343	394	251	686	788	502	1029	1182	753
580	369	217	241	154	362	402	256	723	804	512	1085	1206	768
600	375	228	245	156	380	408	260	761	816	520	1141	1225	780
620	381	240	250	159	400	416	265	799	832	530	1199	1248	795
640	388	251	254	162	419	423	269	838	845	538	1257	1268	808
660	394	263	258	164	439	429	273	878	858	547	1316	1287	820
680	399	275	262	167	459	436	278	918	871	555	1377	1307	833
700	405	288	266	169	479	442	282	958	885	563	1438	1327	845
720	411	300	269	171	500	448	286	1000	897	571	1500	1345	857
740	417	313	273	174	521	455	290	1042	909	579	1563	1364	869

REV. PER MIN.=Revolutions per Minute. H. P.=Horse Power. C. F.=Cubic Feet Water per Minute. M. I.=Miner's Inches.

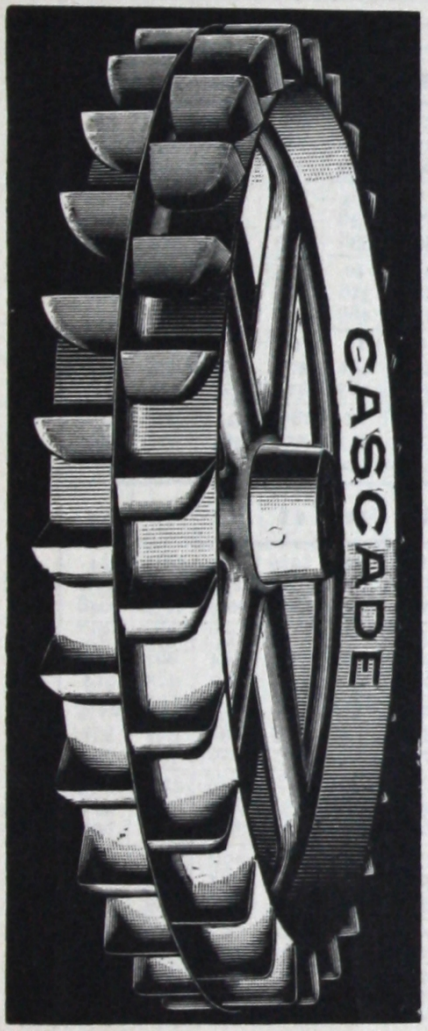
DOUBLE 50 INCH "CASCADE" WATER WHEEL.

Head in Feet.	Rev. per Min.	VENT 2 N.			VENT 4 P.			VENT 5 P.			VENT 6 P.		
		H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.
60	119	14 3/8	155	99	48 1/8	518	330	60	647	412	72 1/4	777	495
62	121	15 1/8	158	101	50 1/2	526	335	63 1/4	658	419	75 3/4	789	503
64	123	16	160	102	53	535	341	66 1/4	668	426	79 1/2	802	511
66	124	16 5/8	163	104	55 1/2	543	346	69 1/2	679	432	83 1/4	815	519
68	126	17 3/8	165	105	58	552	351	72 1/2	691	439	87	827	527
70	128	18 1/8	168	107	60 1/2	559	356	75 3/4	699	445	91	839	534
72	130	19	170	108	63 1/4	567	361	79	709	452	94 3/4	851	542
74	132	19 3/4	173	110	66	575	366	82 1/4	719	458	98 3/4	863	549
76	134	20 1/2	175	111	68 1/2	583	371	85 1/2	728	464	103	874	557
78	135	21 3/8	177	113	71 1/4	590	376	89	738	470	107	886	564
80	137	22 1/4	179	114	74	598	381	92 1/2	747	476	111	897	571
82	139	23	182	116	76 3/4	605	386	96	757	482	115	908	578
84	140	24	184	117	79 3/4	613	390	99 1/2	766	488	119	919	585
86	142	24 3/4	186	118	82 1/2	620	395	103	775	494	124	930	592
88	144	25 5/8	188	120	85 1/2	627	399	107	784	499	128	941	599
90	145	26 1/2	190	121	88 1/4	634	404	110	793	505	132	951	606
92	147	27 3/8	192	123	91 1/4	641	408	114	801	511	137	962	613
94	149	28 1/4	194	124	94 1/4	648	413	118	810	516	141	972	619
96	150	29 1/4	197	125	97 1/4	655	417	121	819	521	146	982	626
98	152	30 1/8	199	126	100	662	421	125	827	527	150	993	632
100	153	31	201	128	103	669	426	129	836	532	155	1003	639
102	155	32	203	129	106	675	430	133	844	538	160	1013	645
104	156	33	205	130	110	682	434	137	852	543	164	1023	651
106	158	33 7/8	207	132	113	688	438	141	860	548	169	1032	657
108	159	34 7/8	208	133	116	695	442	145	868	553	174	1042	664
110	161	35 7/8	210	134	119	701	447	149	876	558	179	1052	670
112	162	36 7/8	212	135	122	707	451	153	884	563	184	1061	676
114	164	37 7/8	214	136	126	714	455	157	892	568	189	1071	682
116	165	38 7/8	216	138	129	720	459	161	900	573	194	1080	688
118	166	39 7/8	218	139	132	726	463	166	908	578	199	1089	694
120	168	40 7/8	220	140	136	732	466	170	915	583	204	1098	700
122	169	41 3/8	222	141	139	738	470	174	923	588	209	1107	705
124	171	42 3/8	223	142	143	744	474	179	930	593	214	1116	711

DOUBLE 50 INCH "CASCADE" WATER WHEEL.

Head in Feet.	Rev. per Min.	VENT 2 N.			VENT 4 P.			VENT 5 P.			VENT 6 P.		
		H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.	H. P.	C. F.	M. I.
126	172	44	225	143	146	750	478	183	938	597	220	1125	717
128	173	45	227	145	150	756	482	187	945	602	225	1134	722
130	175	46	229	146	153	762	485	192	953	607	230	1143	728
132	176	47 1/8	230	147	157	768	489	196	960	611	236	1152	734
134	177	48 1/8	232	148	160	774	493	201	967	616	241	1161	739
136	179	49 1/4	234	149	164	780	497	205	974	621	246	1169	745
138	180	50 1/4	236	150	168	785	500	210	981	625	251	1178	750
140	181	51 1/2	237	151	171	791	504	214	989	630	257	1186	756
142	183	52 1/2	239	152	175	797	507	219	996	634	263	1195	761
144	184	53 1/2	241	153	179	802	511	224	1003	639	268	1203	766
146	185	54 3/4	242	154	182	808	514	228	1010	643	274	1212	772
148	186	56	244	155	186	813	518	233	1016	647	280	1220	777
150	188	57	246	156	190	819	521	238	1023	652	285	1228	782
152	189	58 1/4	247	158	194	824	525	243	1030	656	291	1236	787
154	190	59 1/4	249	159	198	830	528	247	1037	660	297	1244	793
156	191	60 1/2	251	160	202	835	532	252	1044	665	303	1252	798
158	193	61 3/4	252	161	206	840	535	257	1050	669	308	1260	803
160	194	62 3/4	254	162	210	846	539	262	1057	673	314	1268	808
165	197	65 3/4	258	164	219	859	547	274	1073	684	329	1287	820
170	200	68 3/4	262	167	229	871	555	287	1089	694	344	1307	833
175	203	71 3/4	265	169	240	884	563	300	1105	704	359	1326	845
180	206	75	269	171	250	897	571	313	1121	714	375	1345	857
185	208	78 1/4	273	174	260	909	579	326	1136	724	391	1363	869
190	211	81 1/4	277	176	271	921	587	339	1152	734	407	1382	880
195	214	84 1/2	280	179	282	934	595	352	1168	744	423	1401	893
200	217	87 3/4	284	181	293	945	602	366	1182	753	439	1418	903
205	219	91 1/4	287	183	304	957	610	380	1196	762	456	1436	914
210	222	94 1/2	291	185	315	969	617	394	1211	771	473	1453	925
215	225	98	294	187	326	980	624	408	1225	780	490	1470	936
220	227	101	297	189	338	991	632	422	1239	789	507	1487	947
225	230	105	301	192	349	1003	639	437	1253	798	524	1504	958
230	232	108	304	194	361	1014	646	451	1267	807	542	1520	969
235	235	112	307	196	373	1025	653	466	1280	816	559	1537	979

REV. PER MIN.=Revolutions per Minute. H. P.=Horse Power. C. F.=Cubic Feet Water per Minute. M. I.=Miner's Inches.



has been said in the foregoing, regarding this style of wheel, is equally applicable to the other sizes in these tables. The table on foregoing page is for a Double 50-inch Cascade Wheel, or two wheels on the same shaft, each with one, two or three vents.

Power Tables for Small Turbines.

Pages 22 and 23 contain tables of small Standard and Reduced James Leffel Wheels. The sizes on page 22, 8¾ to 17½ inches, are Standards. Page 23 is computed for Reduced capacities, the sizes being xx 13 to xx 23 inches inclusive. This page contains also three Standard capacity wheels. The head pressures range from 5 to 148 feet.

PRICES of Leffel Wheels and Globes.

The prices in the second columns in tables of powers, pages 22 and 23, are for Wheel and Globe complete. The Wheel, as shown at the left hand of inside page of front cover, opposite title page, is placed within the Globe, shown at the right hand of the same page. This Globe and Wheel within are ready for attachment to head pipe or penstock. The smaller wheels have bronze runners, and all having steel gates.

PRICES of Cascade Water Wheels.

The price list below is for the Cascade Wheel, pulley and mounting complete. They are ready for attachment by belt to the machinery, and to the head pipe, leading water to the Wheel. These mountings are all iron, which is far preferable to wood, and not much more expensive. They contain a gate operated by hand, for admitting water to the nozzles, and shutttng it from them. We give the fullest guarantee for each wheel.

HEAD. ☞	60 to 200 Feet.			200 to 400 Feet.			400 to 600 Feet.		
WHEEL.	1 Nozzle.	2 Nozzles.	3 Nozzles.	1 Nozzle.	2 Nozzles.	3 Nozzles.	1 Nozzle.	2 Nozzles.	3 Nozzles.
20	$180	$200	$220	$210	$230	$260	$245	$270	$300
26	$260	280	300	$290	320	350	$340	370	400
38	$370	400	430	$420	450	480	$470	510	
50	$500	550	600	$575	640	710			
60				WRITE FOR DISCOUNTS FROM THESE PRICES.					

 New Table Specially arranged for the James Leffel STANDARD Water Wheels.

Size of WHEEL	Wheel & Globe.	Head in feet	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
10	Bronze **8225** Runner	Power..				1½	1¾	2	2⅜	2⅝	3	3⅜	3¾	4⅛	4½	5	5⅜	5¾	6¼	6⅝	7⅛	7⅝
		Water..				120	123	126	134	138	146	152	158	163	167	173	178	182	188	191	196	201
		Speed..				392	414	436	457	473	497	516	534	551	568	585	601	617	632	647	661	675
11½	Bronze **8235** Runner	Power..				1⅞	2¼	2⅝	3	3½	4	4½	4⅞	5⅜	5⅞	6½	7	7½	8⅛	8⅝	9¼	9⅞
		Water..				146	158	166	172	184	194	202	206	213	218	226	232	236	244	248	254	260
		Speed..				339	359	379	397	415	432	448	464	479	494	508	522	536	549	562	574	587
13¼	Bronze **8250** Runner	Power..				2½	3	3½	4	4½	5¼	5⅞	6½	7¼	7⅞	8⅝	9¼	10	10¾	11⅝	12⅜	13¼
		Water..				197	210	221	230	237	255	265	274	286	293	303	307	316	323	332	340	349
		Speed..				294	312	329	345	360	375	389	403	416	429	441	454	465	477	488	499	510
15¼	Iron **8260** Runner	Power..	1½	2⅛	2¾	3¼	4	4⅝	5⅜	6	6¾	7⅝	8½	9⅜	10¼	11⅛	12	13	14	15	16	17⅛
		Water..	202	224	246	257	281	292	309	316	328	344	358	370	381	390	399	411	421	431	439	451
		Speed..	204	221	239	256	271	286	300	313	326	338	350	362	373	384	394	405	414	424	433	443
17½	Iron **8285** Runner	Power..	2⅛	2¾	3½	4⅜	5⅛	6	7	8	9	10	11	12¼	13⅜	14½	15¾	17	18⅜	19⅝	21	22⅜
		Water..	269	289	316	345	360	379	402	421	437	451	463	484	497	509	524	537	553	564	577	589
		Speed..	176	193	208	223	236	249	261	273	284	295	305	315	325	334	343	352	361	369	378	386

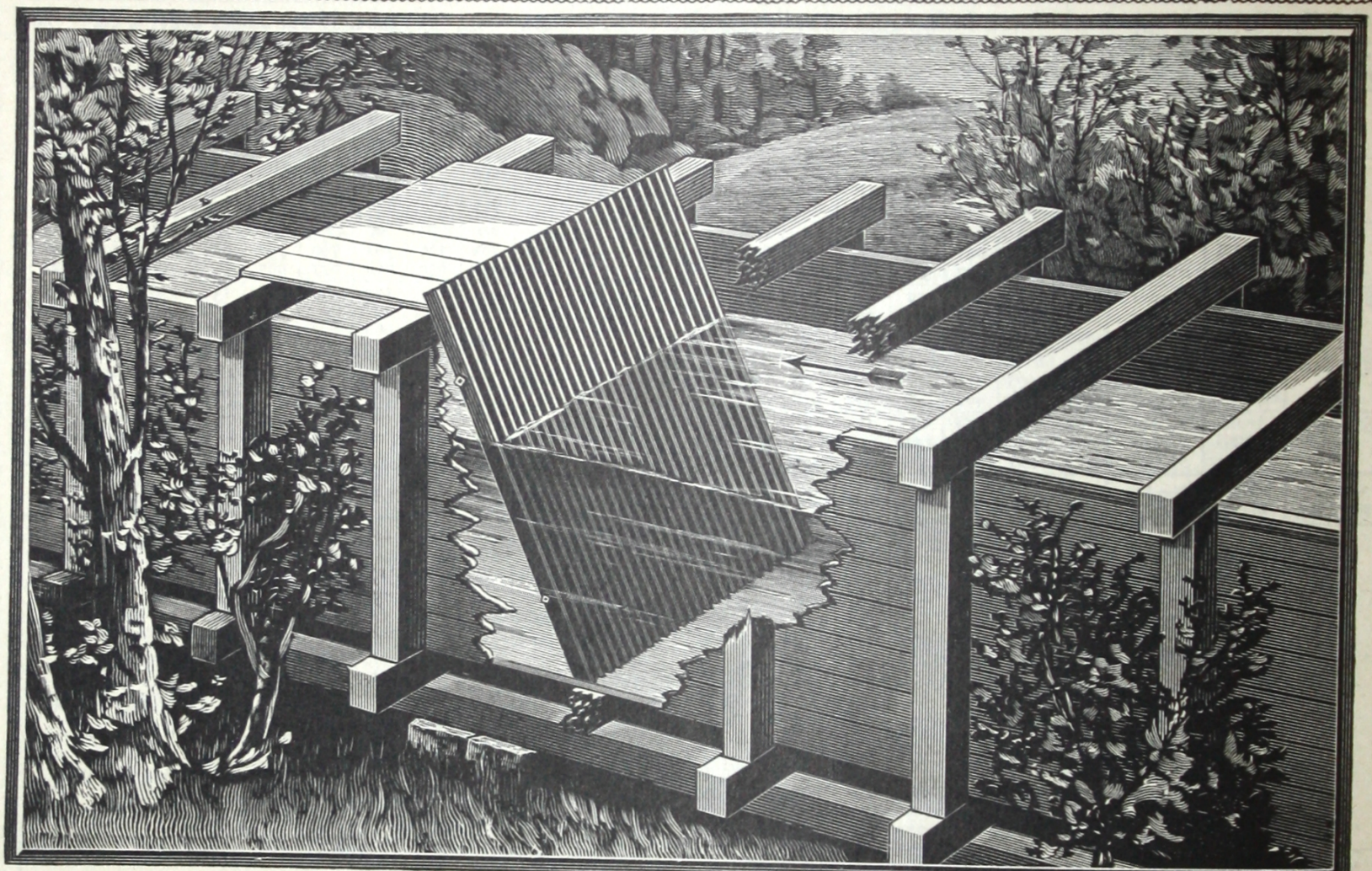
Size of WHEEL	Wheel & Globe.	Head in feet	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
8¾	Bronze **8215** Runner	Power..	6	6⅜	6¾	7⅛	7½	7⅞	8¼	8⅝	9	9½	9⅞	10¼	10¾	11⅙	11⅝	12	12½	13	13½	14
		Water..	151	155	157	159	163	166	168	170	172	176	178	180	183	186	188	190	192	195	198	201
		Speed..	788	803	819	834	848	863	877	891	905	919	923	945	958	971	984	996	1008	1020	1032	1046
10	Bronze **8225** Runner	Power..	8	8½	9	9½	10	10⅝	11⅛	11¾	12¼	12¾	13⅜	14	14⅝	15⅛	15¾	16⅜	17	17⅝	18⅛	18¾
		Water..	202	206	210	214	218	224	227	232	234	237	241	246	250	252	255	259	262	264	266	269
		Speed..	689	703	716	729	742	755	767	780	792	804	816	827	838	850	861	872	882	893	903	914
11½	Bronze **8235** Runner	Power..	10½	11⅛	11¾	12½	13⅛	13⅞	14½	15¼	16	16¾	17½	18¼	19	19¾	20½	21¼	22	22¾	23⅝	24½
		Water..	265	270	275	282	286	293	295	301	306	311	316	320	324	328	332	336	339	342	347	352
		Speed..	599	611	622	634	645	656	667	678	688	699	709	719	729	738	748	758	767	776	785	794
13¼	Bronze **8250** Runner	Power..	14	14⅞	15¾	16⅝	17½	18⅜	19⅜	20¼	21¼	22¼	23¼	24¼	25¼	26¼	27¼	28⅜	29⅜	30½	31⅝	32¾
		Water..	353	361	368	376	381	387	395	401	407	413	419	425	431	436	442	446	453	459	464	470
		Speed..	520	530	540	550	560	570	579	589	598	607	616	624	633	641	650	658	665	674	682	690
15¼	Iron **8260** Runner	Power..	18¼	19⅜	20½	21⅝	22¾	24	25¼	26⅜	27⅝	29	30¼	31½	32¾	34¼	35½	36⅞	38¼	39½	41	42½
		Water..	461	471	480	488	495	505	515	521	528	536	545	553	560	569	575	582	589	595	602	610
		Speed..	452	461	470	478	487	495	503	511	519	527	535	542	550	557	564	572	579	586	593	600
17½	Iron **8285** Runner	Power..	23¾	25¼	26¾	28¼	29¾	31⅜	32⅞	34½	36⅛	37¾	39½	41¼	43	44¾	46½	48¼	50	51⅞	53¾	55¾
		Water..	600	613	626	637	648	660	670	681	692	702	713	724	734	744	753	762	771	780	790	801
		Speed..	394	402	409	417	424	431	439	446	453	459	466	473	479	486	492	498	504	510	516	522

Write for DISCOUNTS from these Prices. POWER=Horse Power. WATER=Cubic Feet per Minute. SPEED=Revolutions per Minute.

Size of WHEEL	Wheel & Globe.	Head in feet☞	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
XX 13¼	Bronze **$275** Runner	Power..	26	28	30	32	34	36	37¾	39½	41¼	43	45	47	49¼	51½	53¾	56	58¼	60½	62¾	65
		Water..	357	368	379	388	397	406	411	416	420	424	430	436	444	452	459	465	471	477	483	489
		Speed..	706	720	735	750	764	778	792	806	819	832	845	858	870	882	895	908	920	930	941	953
XX 15¼	Bronze **$290** Runner	Power..	34	36	39	41½	44¾	47	49½	52	54¾	57½	60½	63½	66¼	69	71¾	74½	77¼	80	83	86
		Water..	466	479	492	504	518	530	539	547	558	567	579	590	598	605	612	619	625	632	639	647
		Speed..	613	626	640	652	664	676	688	700	712	724	735	746	757	768	778	788	798	808	818	827
XX 17½	Bronze **$315** Runner	Power..	45¼	48	50¾	54	57	60	63½	67	71	75	78½	82	85½	89	92½	96	100	104	108	112
		Water..	621	631	641	653	665	677	690	705	723	740	751	762	771	781	790	798	810	821	832	842
		Speed..	535	546	557	568	578	589	600	610	620	630	640	650	659	668	677	687	696	704	712	721
STANDARD 17½	Bronze **$320** Runner	Power..	59¾	64	68	72	76	80	84	88	92¾	97½	102	107	111	116	121	126	131	136	141	147
		Water..	826	842	859	875	889	902	915	926	945	962	977	993	1005	1018	1033	1047	1061	1074	1085	1100
		Speed..	535	546	557	568	578	589	600	610	620	630	640	650	659	668	677	687	696	704	712	721
STANDARD 20	Iron **$365** Runner	Power..	76	81⅜	86⅜	91¼	96½	103	110	116	122	129	135	141	147	153	160	167	173	180	186	193
		Water..	1044	1071	1092	1109	1140	1170	1200	1223	1240	1275	1291	1310	1328	1344	1361	1388	1400	1422	1433	1448
		Speed..	467	478	487	497	506	516	525	534	543	551	559	568	576	585	593	601	609	617	625	632
STANDARD 23	Iron **$425** Runner	Power..	104	111	118	125	133	141	149	156	164	172	180	188	196	205	214	222	231	240	249	258
		Water..	1430	1461	1491	1520	1556	1591	1623	1643	1671	1698	1723	1747	1769	1799	1827	1846	1871	1896	1919	1941
		Speed..	407	416	425	434	442	449	456	463	470	477	484	491	498	507	515	522	529	536	543	550

Size of WHEEL	Wheel & Globe.	Head in feet☞	86	88	90	92	94	96	98	100	104	108	112	116	120	124	128	132	136	140	144	148
XX 13¼	Bronze **$300** Runner	Power..	67¼	69½	71¾	74	76½	79	82	85	89	94	99	104	110	116	121	125	133	139	145	151
		Water..	494	499	503	508	514	520	528	537	545	550	558	565	570	584	698	608	618	627	636	644
		Speed..	964	976	987	998	1009	1020	1030	1040	1060	1080	1100	1120	1140	1158	1178	1196	1214	1232	1248	1266
XX 15¼	Bronze **$325** Runner	Power..	89¼	92½	95¾	99	102	106	109	112	118	125	133	140	147	154	162	169	177	185	193	201
		Water .	655	663	672	680	689	697	702	707	717	731	750	762	774	786	799	810	822	834	847	858
		Speed..	837	647	857	867	877	886	896	906	922	940	956	974	990	1006	1022	1038	1054	1070	1084	1100
XX 17½	Bronze **$345** Runner	Power..	116	120	124	128	132	137	141	146	154	163	172	181	191	200	211	221	231			
		Water..	852	861	870	879	890	901	910	922	935	952	970	987	1005	1023	1041	1057	1073			
		Speed..	731	739	747	757	765	772	780	788	804	818	834	848	862	878	892	906	918			
XX 20	Bronze **$400** Runner	Power..	152	157	162	168	173	179	184	190	201	213	225	237	250	263	276	288	302			
		Water..	1114	1127	1140	1154	1163	1178	1189	1200	1221	1245	1269	1292	1316	1339	1362	1382	1403			
		Speed..	640	647	654	661	668	675	682	690	702	716	730	742	756	768	780	792	804			
XX 23	Iron **$470** Runner	Power..	200	207	214	221	228	236	244	252	267	283	298	315	331	348	364	382	400			
		Water..	1468	1486	1502	1518	1532	1553	1573	1592	1632	1656	1681	1712	1743	1770	1797	1827	1858			
		Speed..	556	562	568	574	581	588	594	600	612	622	634	646	656	667	678	688	700			

Write for DISCOUNTS from these Prices. POWER=Horse Power. WATER=Cubic Feet per Minute. SPEED=Revolutions per Minute.



FOREBAY RACK AND SCREEN.

Forebay, Rack or Screen.

Any kind of Water Wheel, whether Overshot, Hurdy Gurdy, or Turbine, requires a screen to prevent floating obstructions passing into the gates or nozzles. We invariably insist in all cases, upon the use of one or more well constructed racks or screens, in the flume or at the mouth of the head pipe; as a necessary precaution at all times against drift or leaves. The opposite page shows one of the simplest methods of constructing and placing a rack, which may be made of iron or thin pieces of wood. Iron is perferable as the pieces can be thinner than wood, occupying much less space. The simplest arrangement of these pieces, whether iron or wood, is to place them side by side in a line, each piece having two or more holes, so that rods can pass through the pieces from one side of the rack to the other, with nuts on the ends of the rods to hold the pieces firmly together. Upon these rods between each piece, an iron or wooden washer of proper thickness can be placed, leaving spaces for the water to pass. The large nozzel wheels admit of coarse spaces between them.

When two or more racks are used, the furthest one up stream may have large spaces for catching most of the heavy drift; lessening the labor of cleaning a finer rack, which must have frequent attention to prevent loss of head, which occurs if they are neglected. Small nozzles require small spaces or meshes in the racks or screens. A coarse brass wire screen is excellent, as it does not rust in water. The meshes in this wire screen must always be less than the opening of the nozzle, which is used on the wheel. If the nozzle should be a half inch, then the meshes in the screen should be three-eighths. If the nozzle has an inch opening, the meshes should be three-quarters to seven-eighths inch. The cross section of the flume or pipe, where the racks or screens are placed, should be much larger than the average size of pipe, for the free and easy passage of water, that it may supply a sufficient quantity when partly clogged. Several wire screens on wooden frames could be so placed, as to admit of quick and easy removal and replacement, for the purpose of cleaning; one or more always remaining while one is removed. Great care must always be exercised to keep the rack and nozzle clean, to prevent loss of head and power.

Artesian Well Water Powers.

Frequently inquiries are made, concerning the amount of power that can be obtained from artesian wells. The idea generally prevails, that they should supply considerable power, as there is always apparently a large quantity of water flowing from each well. This idea of power arises from the fact, that a high pressure is always obtained when the pipe is capped over or closed, and the water is supposed to flow under that pressure, when discharging from the open well at the surface. Our long experience however in the wheel business, and the many instances brought to our attention, have presented very few practical and successful powers from this source. Very small powers are quite often obtained from wells properly connected with motors, but large powers are exceedingly rare. It is not generally understood, that the flow occurs nearly always under a very low pressure; and that a high pressure on the other hand, is obtained when the flow is very small. Either of these conditions being unfavorable, to the development of sufficient power for large concerns. The well tubing is so small, and often so deep, that the necessary conditions of quantity and pressure rarely happen together. Occasionally a well is located on an eminence, where reservoir can be secured. Such a circumstance admits of the use of a larger wheel,

Table showing Loss of Head by Friction in Pipes.

Diam. Inches.	Vel. in Feet per Sec. ☞ / Area ☜	1		1½		2		2½		3		4		5		6		7		8		9		10	
		B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C
1	.785	.33	.58	.49	1.201	.66	2.	.99	2.959	.99	4.08	1.3	6.833	1.6	10.25	1.9	14.33	2.3	19.08	2.6	24.5	2.9	30.58	3.2	37.33
2	3.141	1.3	.29	1.9	.600	2.62	1.	3.9	1.479	3.9	2.04	5.2	3.416	6.5	5.125	7.8	71.65	9.1	9.541	10.5	12.25	11.8	15.296	13.0	18.66
3	7.068	2.9	.194	4.3	.400	5.88	.67	8.7	.986	8.8	1.36	11.7	2.277	14.7	3.146	17.7	4.777	20.5	6.361	23.5	8.166	26.4	10.194	29.4	12.44
4	12.566	5.2	.145	7.8	.300	10.5	.50	15.7	.739	15.7	1.02	20.9	1.708	21.2	2.56	31.4	3.582	36.7	4.77	41.9	6.125	47.2	7.895	42.4	9.333
5	19.63	8.1	.117	12.1	.240	16.3	.40	24.4	.592	24.4	.816	32.5	1.366	40.7	2.05	48.8	2.866	56.9	3.816	65.1	4.9	73.3	6.116	81.4	7.466
6	28.27	11.8	.096	17.7	.200	23.5	.33	35.2	.493	35.3	.680	47.1	1.139	58.9	1.71	70.6	2.39	82.4	3.18	94.2	4.08	106.	5.097	117.8	6.222
7	38.48	16.0	.083	24.	.171	32.0	.28	48.	.422	48.	.583	64.1	.976	80.1	1.46	96.1	2.047	112.	2.726	128	3.5	144	4.37	160	5.333
8	50.26	20.9	.073	31.	.150	41.8	.25	63.	.370	63.	.51	83.7	.855	104	1.28	126	1.79	146	2.385	168	3.062	188	3.823	208	4.666
9	63.61	26.5	.065	40.	.133	53.0	.22	79.	.328	80	.454	106	.759	133	1.14	159	1.592	186	2.12	212	3.933	239	3.4	266	4.148
10	78.54	32.7	.058	49.	.120	65.4	.20	98.	.295	98	.408	131	.683	163	1.025	196	1.433	229	1.908	261	2.45	294	3.058	326	3.733
11	95.03	39.6	.052	59.	.109	79.2	.18	118	.269	120	.371	160	.621	200	.98	238	1.30	277	1.735	317	2.22	356	2.78	400	3.394
12	113.	47.1	.048	71.	.100	94.2	.16	141	.247	141	.340	188	.570	235	.85	283	1.19	330	1.59	377	2.04	424	2.55	470	3.111
13	132.7	55.3	.045	83.	.092	110	.15	165	.229	166	.313	231	.526	277	.79	332	1.10	387	1.467	442	1.88	498	2.352	544	2.872
14	153.9	64.1	.041	96.	.078	128	.14	192	.211	192	.292	257	.488	321	.73	385	1.02	449	1.363	513	1.75	577	2.184	642	2.666
15	176.7	73.6	.039	110	.080	147	.13	220	.197	221	.272	294	.455	368	.68	442	.95	515	1.275	589	1.63	663	2.04	736	2.49
16	201.	83.7	.036	125	.075	167	.12	250	.185	251	.255	235	.427	419	.64	502	.89	586	1.192	670	1.53	754	1.91	838	2.333
17	226.9	94.5	.034	141	.070	189	.12	283	.174	284	.240	378	.402	473	.60	567	.85	662	1.122	757	1.44	851	1.8	946	2.196
18	254.	106.	.032	159	.066	212	.11	318	.164	318	.227	424	.380	530	.57	636	.79	742	1.06	848	1.36	954	1.7	1060	2.074
19	283.	118	.030	177	.063	236	.105	354	.155	354	.215	473	.360	591	.54	709	.75	827	1.00	945	1.29	1063	1.61	1182	1.965
20	314.	130	.029	195	.060	261	.100	391	.147	393	.204	523	.341	654	.51	785	.71	916	.954	1047	1.225	1178	1.53	1308	1.866
22	380.	158	.026	237	.055	317	.091	475	.134	475	.185	633	.311	791	.46	950	.65	1109	.867	1267	1.11	1425	1.39	1582	1.697
24	452.	188	.024	282	.050	377	.083	565	.123	565	.170	753	.285	942	.42	1131	.59	1320	.795	1508	1.02	1697	1.27	1884	1.55
26	530.	221	.022	331	.046	442	.077	663	.114	664	.157	884	.263	1106	.394	1327	.55	1559	.736	1770	.94	1991	1.176	2212	1.43
28	615.	256	.021	384	.042	513	.071	769	.108	770	.146	1026	.244	1282	.366	1539	.51	1796	.681	2052	.87	2309	1.092	2564	1.33
30	706.	294	.019	441	.040	589	.066	888	.098	883	.136	1177	.228	1472	.341	1767	.48	2062	.636	2356	.82	2651	1.019	2944	1.24
32	804.	335	.018	502	.037	670	.062	1005	.092	1005	.127	1340	.213	1675	.32	2011	.44	2346	.596	2681	.76	2916	.955	3350	1.16
34	907.	378	.017	567	.035	756	.059	1134	.087	1135	.120	1513	.201	1891	.301	2270	.42	2648	.561	3026	.72	3405	.899	3782	1.09
36	1017.	424	.016	636	.033	848	.055	1272	.082	1272	.113	1696	.189	2120	.285	2544	.39	2969	.53	3393	.68	3817	.849	4240	1.03
38	1134.	472	.015	708	.031	945	.052	1417	.078	1417	.107	1890	.180	2362	.27	2835	.37	3308	.502	3780	.64	4253	.805	4724	.982
40	1256.	523	.014	784	.030	1047	.050	1570	.074	1571	.102	2094	.171	2617	.256	3141	.36	3665	.477	4189	.612	4713	.764	5234	.933
42	1385.	577	.013	865	.028	1154	.047	1731	.070	1732	.097	2309	.162	2886	.244	3464	.34	4041	.456	4619	.583	5196	.728	5772	.888
48	1809.	754	.012	1131	.025	1508	.041	2262	.061	2262	.085	3015	.142	3769	.213	4524	.30	5278	.397	6032	.51	6786	.637	7538	777
54	2290.	954	.010	1431	.022	1909	.037	2863	.055	2863	.075	3816	.126	4771	.19	5725	.26	6680	.353	7624	.45	8589	.566	9542	.691
60	2827.	1178	.009	1767	.020	2356	.033	3534	.049	3534	.068	4712	.113	5890	.170	7068	.24	8246	.318	9425	.408	10603	.509	11780	.622

B.—Discharge per minute in cubic feet. C.—Number of feet loss by friction, for each 100 feet of pipe.

by running part of the time, than if the flow was taken direct from the well. That a party may obtain approximately, the amount of power a well affords, a measurement of the presure ought to be obtained, at or near the surface of the ground, while the discharge is taking place. Greater accuracy would be secured if a hole or nozzle of 1 ½ or 2 inches was discharging from the well at the time the pressure was measured. A record of the size and shape of the hole, and the pressure should be made, and from this data, the power estimated. The exact height at which ths water would spout, taken with the size of the nozzle, would also admit of estimating the power with considerable accuracy. We will any time answer fully any inquiries on the subject.

Loss of Head by Water Friction in Pipes.

The foregoing table is taken from a book published by James Leffel & Company on the construction of Mill Dams, Millwrighting, and Mechanics. The table has been modified to some extent, giving a velocity of the water per second not exceeding 10 feet, and embracing smaller and larger pipes, compiling and adapting it more fully to this edition of catalogue. The calculations for this table have been accurately made by formula deduced from a co-efficient for roughness of pipe, representing an average which we find quoted, for ordinary wrought iron riveted pipe, by some of the most eminent hydraulic engineers, who had the advantage of making extensive experiments. Our formula thus deduced affords results of sufficient accuracy to estimate loss of head, due to friction, in all cases within the scope of the table. It is useful in estimating the available power of water, moving through varying lengths of pipe, at velocities from 1 to 10 feet per second, in pipes ranging from 2 to 60 inches diameter. It should be remembered that the length of pipe, for which this table has been calculated, is 100 feet. The loss of head by friction varies in the same direct ratio as the length of the pipe; therefore, the amount of such loss, in a pipe of greater or less length than 100 feet, can easily be ascertained, as we hereinafter show. The first horizontal line at top indicates the velocity of flow of water from one to ten feet per second. The first perpendicular column at left indicates the inside diameters of pipe from 2 to 60 inches. We give in the second vertical column the areas in square inches of the different diameters of pipe. The third and fourth perpendicular columns, headed B and C, as also all the subsequent perpendicular columns headed in the same way, indicate the discharge of water and loss of head; the discharge being cubic feet per minute through the different diameters of pipe. The column C show the loss of head in feet and parts of a foot for every 100 feet length of pipe.

That the foregoing may be more easily understood, we give the following example: Supposing it is desired to find the total loss of head for a fall of 200 feet, the water passing through a pipe 5 inches in diameter and 600 feet long, discharging about 40 cubic feet of water per minute: Taking the 5-inch pipe, and running on the same horizontal line in column B under 5 feet velocity of flow of water per second, 40.7 (forty and seven-tenths) cubic feet of water will be found discharged per minute. In the adjoining column to this amount, 2.05 (two and five-hundredths) of a foot loss of head will be found for every 100 feet length of pipe. Having 600 feet length of pipe, we multiply 2.05 by 6, which is the number of hundreds of feet of pipe, the result being 12.3 (twelve and three-tenths) feet; which is the total loss of head for 600 feet length of 5-inch pipe, allowing the water to flow 5 feet per second. Now, by deducting the 12.3 feet

LONG AND CROOKED HEAD PIPE. (SEE FOLLOWING PAGE.)

from the 200 foot head, there remains 187.7 (one hundred and eighty-seven and seven-tenths) feet of actual or effective working head in this example. Where a still greater degree of accuracy is required, a further very small and unimportant loss is sometimes estimated for the "velocity head" and for the "entry head."

Long Head Pipes and their Proper Setting.

The forgoing page shows a long, crooked, head pipe, supplying one of our small water wheels, now in use under a head of 100 feet. Correspondents frequently desire to know, whether the same power can be obtained by using piping, as may be had from ordinary open flumes, carrying the water to a point perpendicularly over the wheel. The illustration is intended to demonstrate, by an instance long in practice, that the same power or useful effect, can be realized by the use of a pipe, placed at an inclination and conforming with the contour of the ground, as if the water was led to the wheel, from a point directly over it. The power in the stream, depends entirely upon the perpendicular distance, between the tail water level and the head water level, and the length and position of the pipe does not effect the power, providing it is sufficiently large to carry the water to the wheel, at a low velocity. A serious loss of head pressure or power frequently results, by the friction of the water, in its passage through a long pipe, if the velocity is considerable, as will be seen by the exhaustive table we have computed and published on page 26. In instances, where the water supply, and also the head pressure are both limited, the size of the pipe should be carefully calculated and conformed to these conditions, that both may be economized to the greatest extent, consistent with the cost of the improvement. Abrupt and square turns or angles, should always be avoided where possible, and long, easy curves adopted, to ease the flow and lessen the friction.

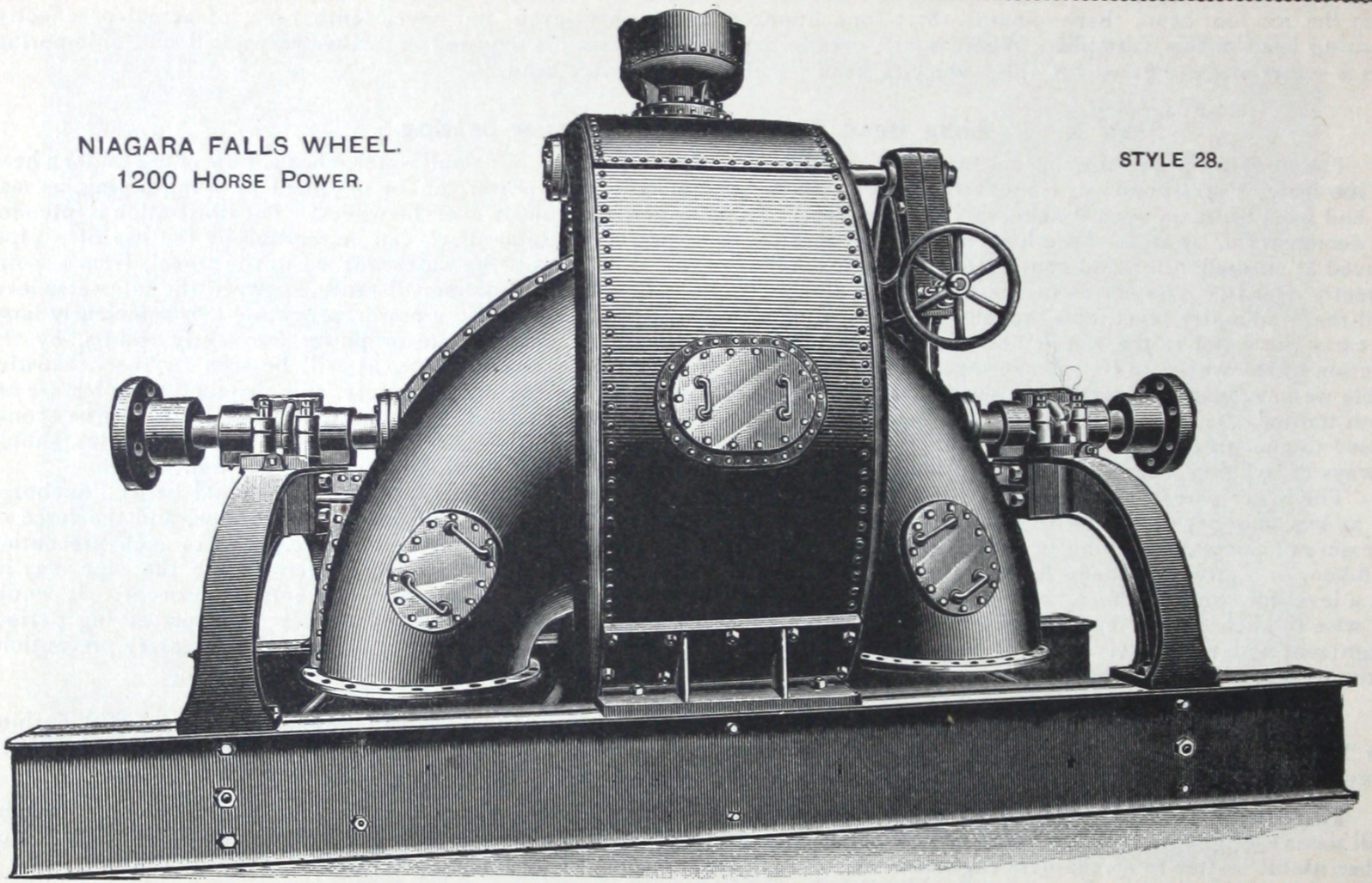
The lower part of the pipe near the wheel, where it is attached to the wheel frame or casing, should be well anchored to strong masonry or otherwise securely fastened. This is necessary to prevent the weight of the pipe, and the force or pressure of the water moving in the pipe, from pushing the wheel and its mounting out of line. Unless such precaution is taken, or a provision made for restraining this usually unobserved or unforeseen pressure, even though the pipe may lie on a level for some distance, before connecting to the wheel, serious displacement will certainly often occur. It would be wise to anchor long, heavy pipes, at several points on the line; but especially is it necessary for preserving perfect alignment and to entirely prevent pressure, against the wheel case and foundation, to observe the necessary precautions intimated in the foregoing.

3000 Complimentary Letters on File. James Leffel & Co., have been building the James Leffel Turbine for THIRTY-TWO YEARS; in this time several thousand letters have been received, from users of this Celebrated Wheel, containing terms of highest praise of its performance. These are on file in the office of the company.

Leffels' Book of Mill Dams, an illustrated book of 286 pages, devoted largely to construction of practical mill dams designed by James Leffel & Co., with also various designs by other competent engineers. It contains much other useful matter to mechanics, engineers and millwrights. Published by James Leffel & Co. Price 50 cents.

NIAGARA FALLS WHEEL.
1200 HORSE POWER.

STYLE 28.



DOUBLE DISCHARGE WATER WHEEL FOR NIAGARA FALLS, 1200 H. P.

Powerful Turbines for Niagara.

The opposite page shows the outward appearance of one of a plant of wheels, recently furnished the Cliff Paper Co., of Niagara Falls. It is our new style of James Leffel Double Discharge Wheel, admitting the water between the steel foundation beams below, discharging horizontally from the wheel on each side, and finally passing down on each side of the mouth piece or supply pipe. The Casing is built of steel plates, and cast iron heads, substantially secured by stay bolts. The shafting is of the best hammered scrap, and the runner, which is 67 inches in diameter, making 225 revolutions per minute, is made of bronze, except hub and arms, all however unusually heavy and strong. The gates are steel, and are operated by our new Patent Balance Thrust gate arrangement. The weight of the entire wheel as shown in the illustration, is 30 tons. They were sold under a guarantee of durability, and against breakage of any kind for a stated time, and to perform satisfactorily a specified amount of work in a given period.

Both these wheels are supplied, from one pipe of 8 feet diameter, leading from a canal at the top of the cliff to the wheel house, affording a head pressure of 130 feet. A large air chamber is placed on the top of casing, which is shown partly broken away in the cut. This chamber relieves any pounding or concussion, that might occur during sudden irregular supplies of water, to the wheel from the canal or head pipe. The wheels are rated at something over 1100 H. P. each, the two giving nearly 2400 Horse Power; making over 30 tons Dry Pulp per day. Each wheel ss connected on each side directly to the large wood grinders, and the other machinery, without the use of gears, pulleys, or belts; affording the simplest and most effective Water Wheels, and the finest Power Plant that can possibly be adapted.

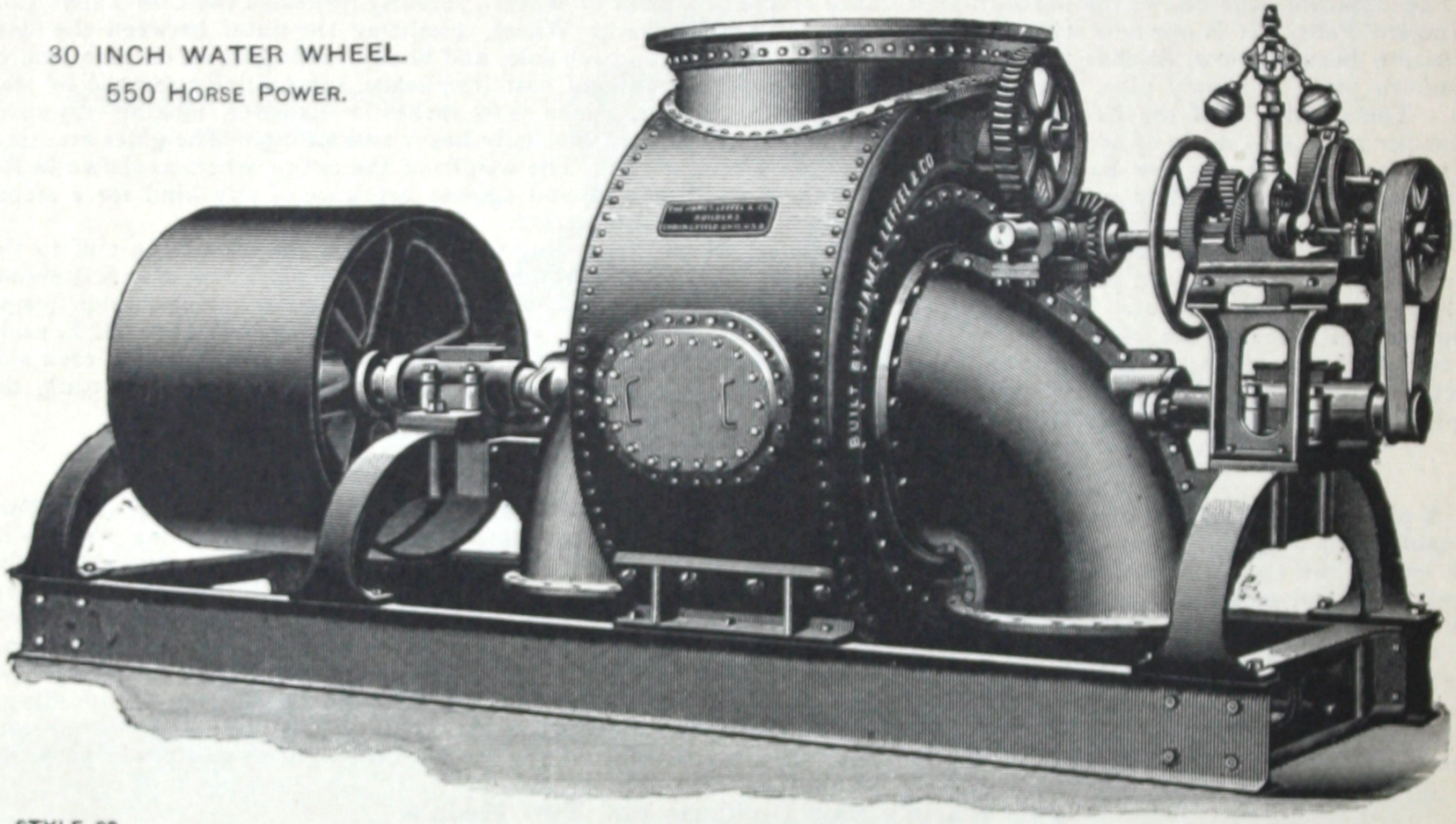
1700 Horse Power; 17 Miles Transmission.

A plant of three pairs of Samson 20 inch Turbine Wheels, with horizontal shafts, is successfully operating at the Falls of Juanacatlan, Mexico. They are the James Leffel Style 21, illustrated in our large Turbine Pamphlet, having a pulley on each end of the shaft, on both sides of the wheel, each pulley containing 16 grooves, for hemp rope transmission. The wheels of the plant are also supplied, each with a Governor, as shown in the illustration on the following page (32) herewith. Each pair of these 20 inch SAMSON Wheels, is nominally rated 600 H. P. Two pairs transmitting electrically about 1100 H. P. to Guadalajara, a distance of nearly 18 miles. These were first put into practical service, the performance of which was so satisfactory, that a third pair was ordered, to fully complete the plant, and afford a reserve power. The runners are made of bronze, shafts of best hammered iron, and gates with other smaller parts of steel; affording a style and make of wheel, without an equal, in beauty of design, in durability, in ease of operation, and in its general satisfactory performance. These wheels are under a head pressure of 62 feet, and are used for lighting and power purposes.

Two World's Fair Diplomas and Two Medals.

The Columbian Exposition have awarded James Leffel & Co., Two Diplomas and Two Medals for their excellent work exhibited at Chicago. The Medals are the highest awards issued by the Exposition for Water Wheels.

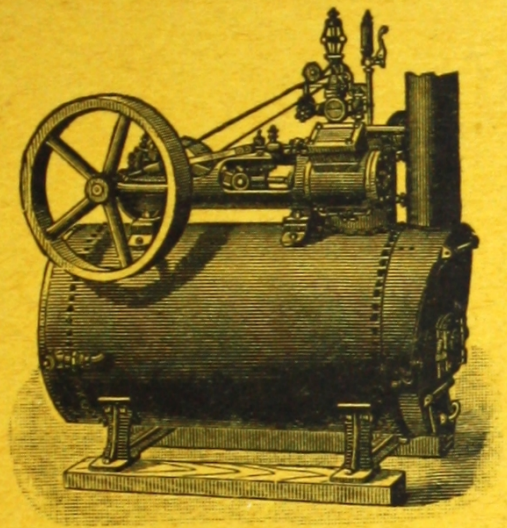
30 INCH WATER WHEEL.
550 HORSE POWER.



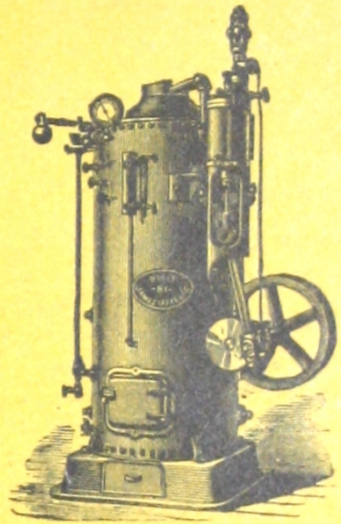
STYLE 23.

NEW DESIGN DOUBLE DISCHARGE JAMES LEFFEL WATER WHEEL.

ENGINES and BOILERS.

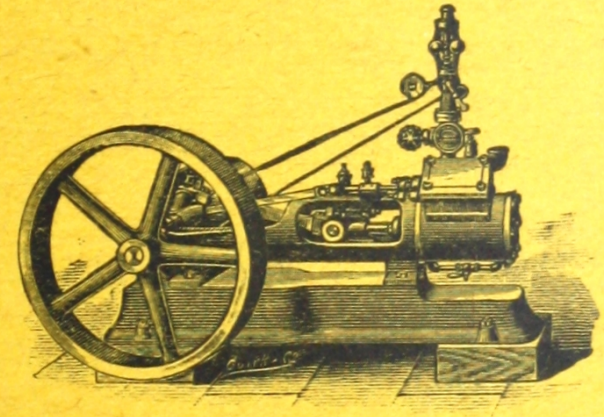


Brief mention is here made of our Engines and Boilers, in the manufacture of which we were early engaged. The high reputation achieved by the splendid success of our Water Wheel in furnishing power resulting in our receiving many applications for steam power also. That our efforts to meet this demand in the fullest measure have been successful, is abundantly attested by more than 4,500 we have introduced giving excellent results.



Horizontal, Centre-Crank, Engines and Self-Contained, Return Flue Steel Boilers, we now build in a large number of sizes, above,

5, 8, 10, 16, 20 and 26 Horse Power.

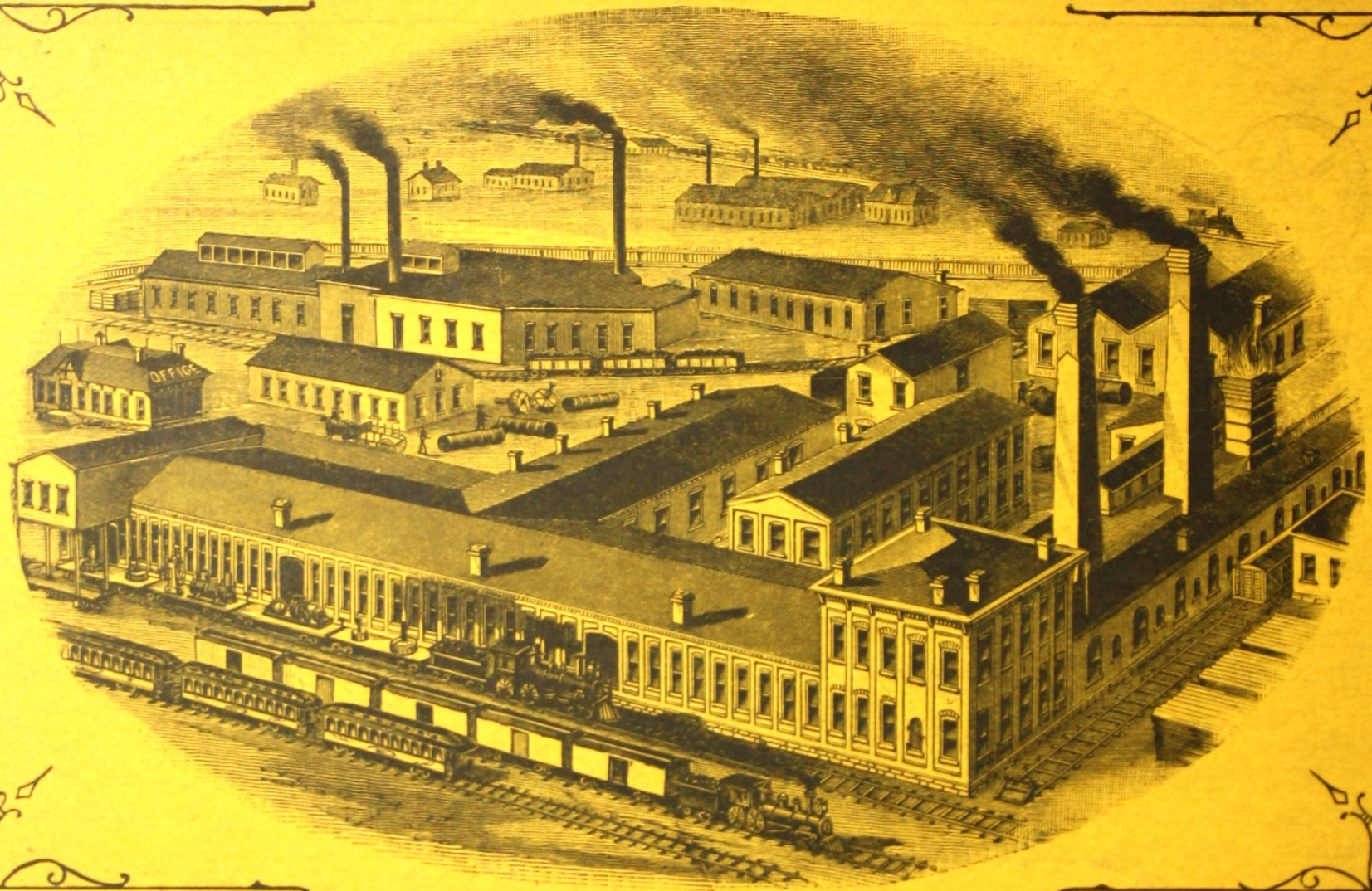


Improved Upright Engines, with Submerged Tubular Steel Boilers. We furnish in various sizes, above,

3, 4½ and 6½ Horse Power.

We publish a separate Pamphlet devoted exclusively to illustrating and describing our Engines and Boilers. Copy of which, with prices, will be sent on application, stating power wanted, or kind and size machinery to be driven.

JAMES LEFFEL & CO., Springfield, Ohio, U. S. A.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